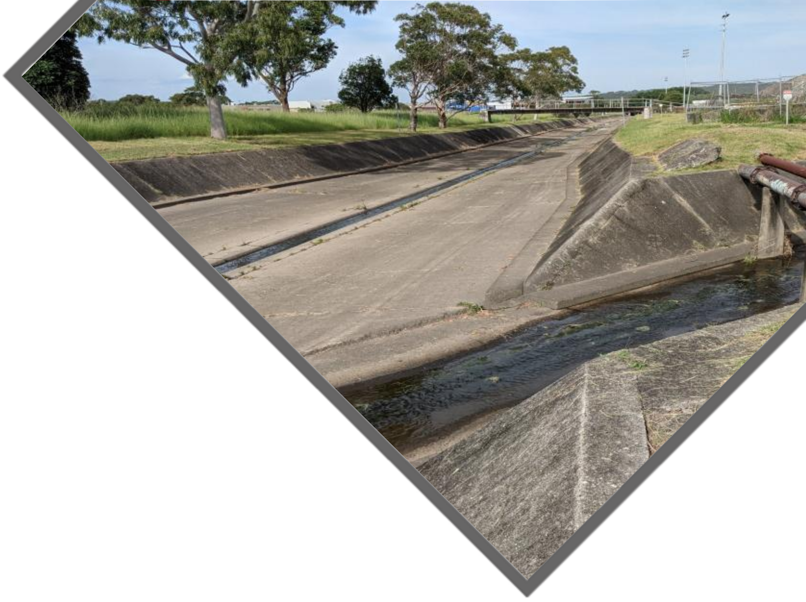

Housing the Hunter: a plan for renewal at Broadmeadow – Flooding and Water Cycle Management

Emerging Scenario Report

Department of Planning, Housing and Infrastructure

RR-03-1820-03

March 2025

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Document Control

Ver	Effective Date	Description of Revision	Prepared by:	Reviewed by:
00	December 2023	Draft for comment	JRF/JPS	LCC
01	May 2024	Final for Public Exhibition	JRF/JPS	LCC
02	February 2025	Figure updates	JPS	JRF
03	March 2023	Table updates	JRF	

Prepared For: Department of Planning, Housing and Infrastructure

Project Name: Housing the Hunter: a plan for renewal at Broadmeadow – Flooding and Water Cycle Management

Rhelm Reference: J1820

Document Name: RR-03-1820-03 Broadmeadow Precinct Flooding and WCM.docx

Executive Summary

Broadmeadow has been identified by the NSW Government as a 'Regionally Significant Growth Area' in the NSW Government's Hunter Region Plan 2041 with Broadmeadow providing a strategic opportunity for sustainable growth. 'Housing the Hunter: a plan for renewal at Broadmeadow ' is a state-led initiative to allow for the redevelopment of the Broadmeadow Precinct (herein referred to as the precinct) to bring growth and opportunities for the surrounding communities.

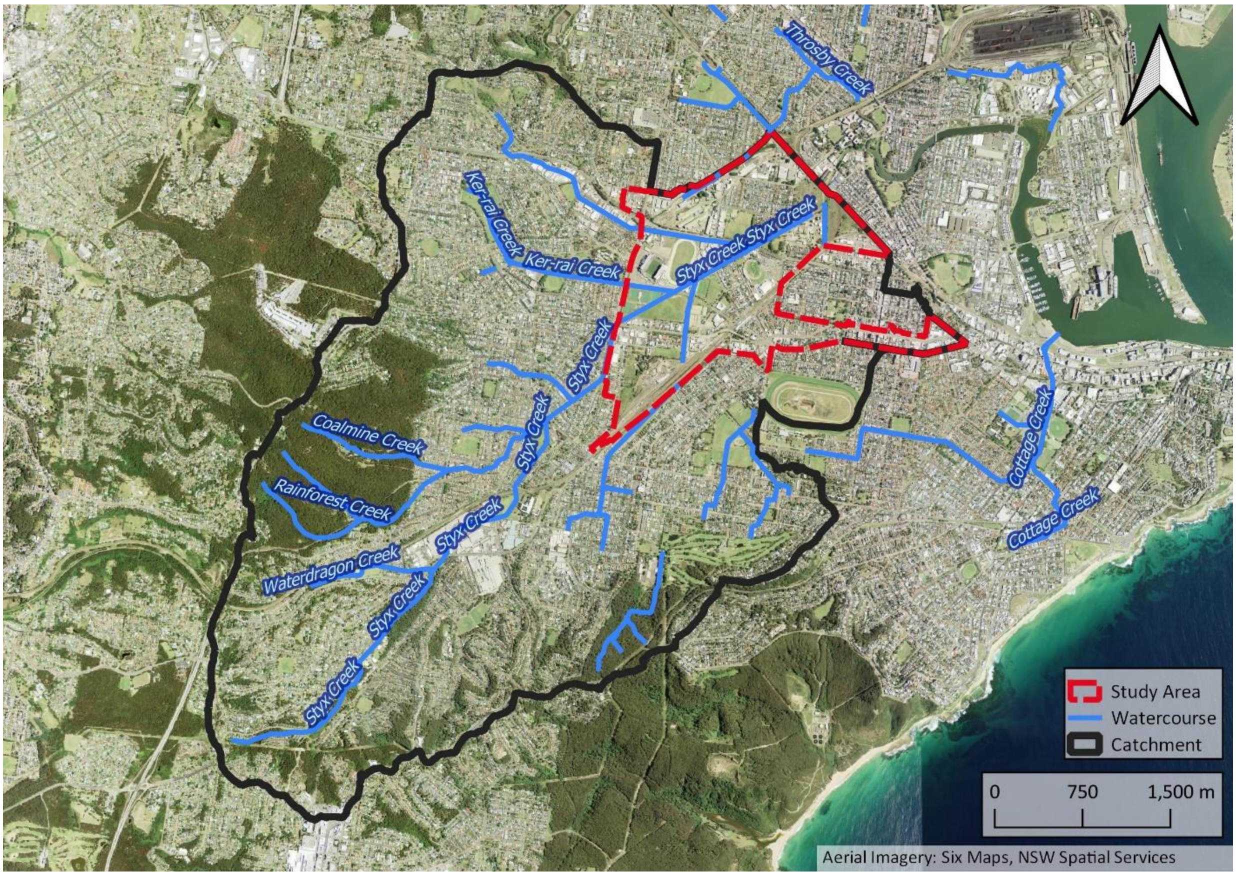
Rhelm has undertaken a flooding and water cycle management assessment based upon the Emerging Scenario land use layout developed by Cox Architects in support of the planning proposal.

This assessment addresses:

- Baseline flooding and water quality conditions,
- Flood impacts and risk,
- Flood emergency management, and
- Water cycle management.

Site Overview

The study area is 313 ha and largely centred in Broadmeadow, NSW, approximately three kilometres west of the Newcastle Central Business District (CBD). The Precinct is predominantly located within the Styx Creek catchment (a tributary of the Hunter River). The total catchment area draining to the Precinct downstream limit is approximately 2,280 ha.



Precinct in the Context of the Catchment

The area is relatively flat and low lying, being located in what was once alluvial floodplain and marshland (prior to colonisation). All of the creeks in the locality have been converted into concrete lined channels throughout Broadmeadow (the Styx Creek catchment).

Current land uses include a mix of low density residential, industrial, commercial, institutional (schools and sporting facilities), as well as major rail and road transport routes.

Data and Literature Review

A comprehensive data and literature review was undertaken to collate the available data relevant to the study, and to review applicable design guidelines to inform the development of the flooding and water cycle management assessment. The review considered data from:

- City of Newcastle (Council),
- Department of Planning, Housing and Infrastructure (DPHI), and
- Technical reports and models relevant to the Precinct.

Baseline Analysis

Flooding

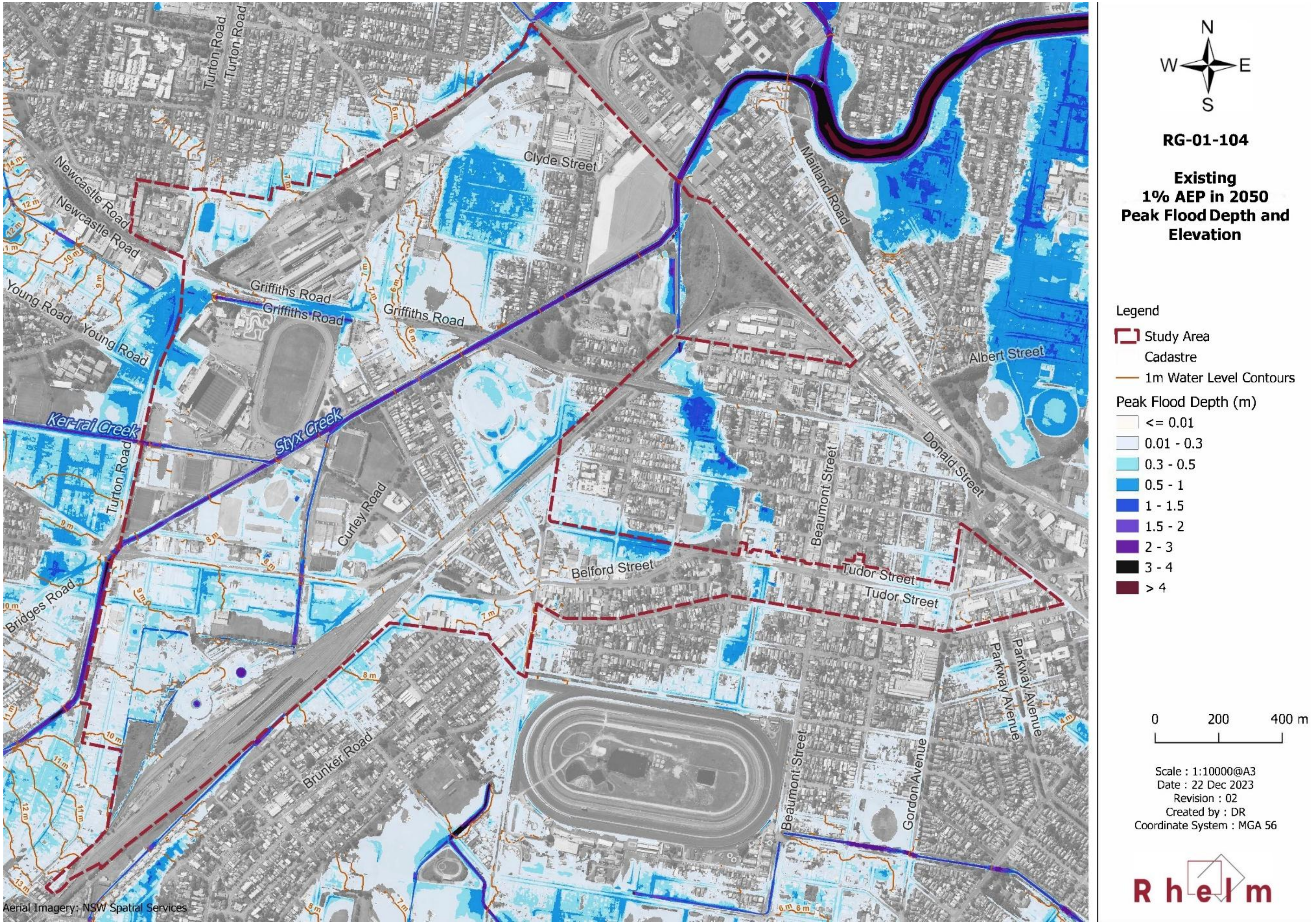
The most recent Council-commissioned flood study covering the Precinct is the Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023). Modelling results from this study were used to define baseline flood behaviour across the Precinct. The City of Newcastle has adopted the defined flood event (DFE) to be the 0.5% Annual Exceedance Probability (AEP) catchment event with appropriate sea level rise, or in other words the 1% AEP event with projected climate change effects on rainfall and sea level rise incorporated to 2050. The DFE is typically used as a basis for planning purposes to set flood planning areas and flood planning levels combined with an appropriate freeboard.

With respect to the Broadmeadow Precinct, flooding begins to affect existing properties in mapped events as frequent as the 10% AEP. It is possible that areas are flooded in even more frequent events; however, these have not been assessed in this study.

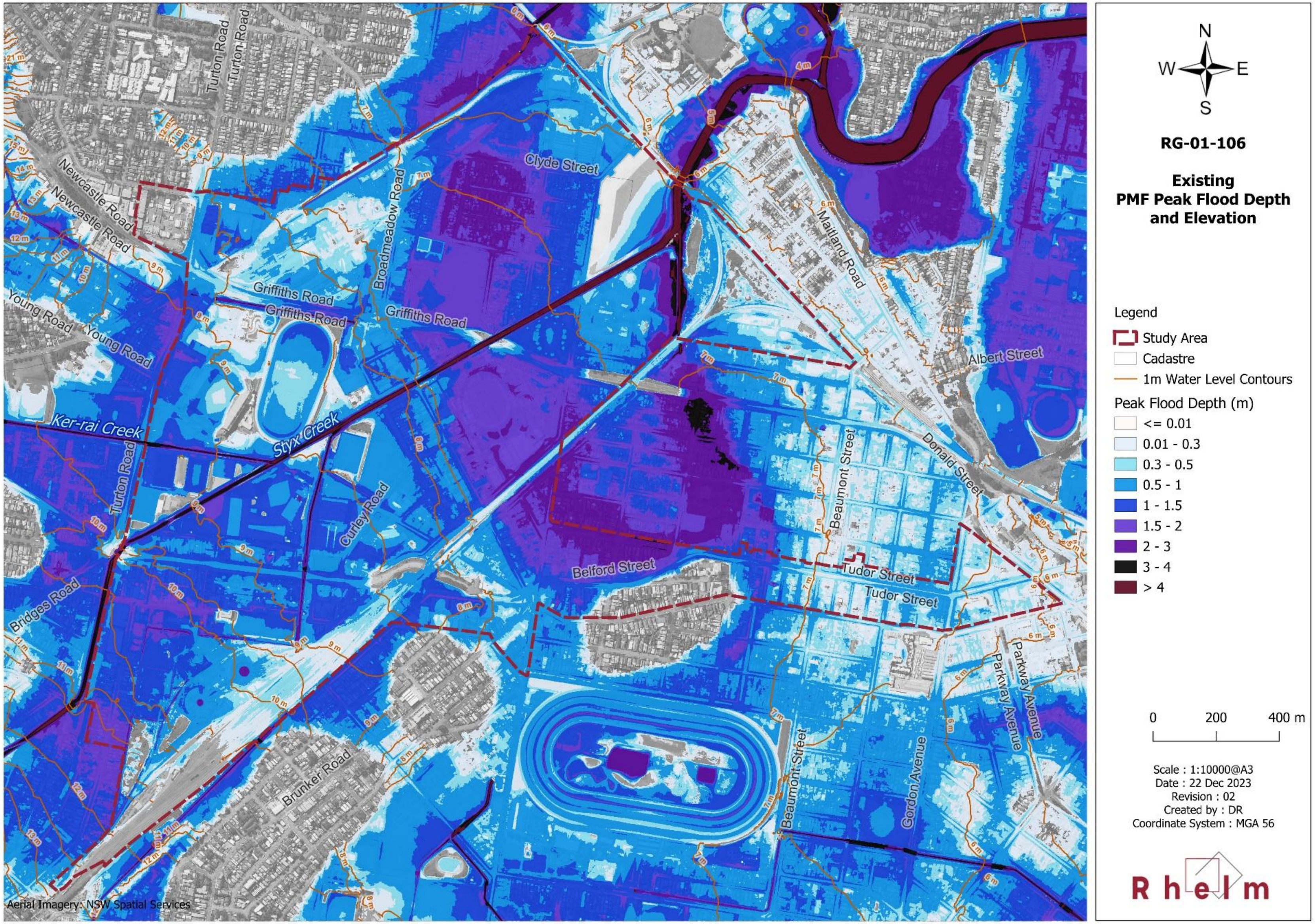
The most frequently and significantly flooded areas include:

- ***South of Lambton Road and west of Styx Creek***. This is caused by breakouts of flood water from Styx Creek upstream near St James Road then re-entering the creek at Lambton Road. Flood waters can be fast moving with high hazard ratings, up to H4 (unsafe for pedestrians and vehicles) along roadways in the 1% AEP event.
- ***East of Broadmeadow Road between Styx Creek and Belford Street, near the Newcastle Entertainment Centre***. At this location, there is inadequate drainage capacity to convey runoff to Styx Creek and ponding occurs. Flood hazards here are lower with relatively slow-moving flood waters.
- ***East of Broadmeadow Road between Styx Creek and Clyde Street***. At this location, there is also inadequate drainage capacity to convey runoff, although the stormwater network here directs runoff to both Styx Creek (to the south-east) and Throsby Creek (to the north-east).

The maps below show the existing peak flood depths and elevations for the 1% AEP in 2050 and the Probable Maximum Flood (PMF).



Existing Conditions Peak Flood Depth and Elevation – 1% Annual Exceedance Probability in 2050



Existing Conditions Peak Flood Depth and Elevation – Probable Maximum Flood

In the PMF, flooding is widespread and only a few small areas of any significance in the Broadmeadow redevelopment area remain flood free. These being:

- Belford Street east of Chatham Street,
- The northwest corner of the Turton Road and Newcastle Road intersection,
- A portion of the property east of Clyde Street and west of Styx Creek, and
- The southern extent of the Transport for NSW rail line east of Adamstown Station.

In the PMF, flood hazards extend up to a classification of H5 (unsafe for some buildings) in private property and along roadways with significant risk for loss of life. H6 (unsafe for buildings) flood hazard is present within the concrete channels of Styx Creek and its tributaries.

Stormwater Drainage

Stormwater drainage ranges from a network of local pits and pipes that converge to larger pipes referred to as the *trunk drainage system*. Trunk drainage ranges from larger circular pipe culverts through to large box culverts and open concrete-lined channels. These features are represented as one-dimensional (1D) elements in the flood model. Stormwater drainage normally seeks to safely convey runoff from events up to the 1 in 10 AEP event.

Interrogation of the results from the one-dimensional (1D) component of the flood model revealed that the majority of trunk stormwater drainage lines within the Precinct are either operating at capacity or surcharging in both minor and major storm events.

Water Cycle Management

New development within the Precinct is currently subject to the provision of on-lot water cycle management requirements specified in Section C4 of the *Newcastle Development Control Plan* (DCP) *2023*.

Existing regional stormwater treatment infrastructure within the Precinct is limited, consisting of a CDS gross pollutant trap (GPT) at the downstream end of Ker-rai Creek and an open GPT adjacent to the Westpac Rescue Helicopter site. GPTs provide a primary treatment to remove litter, debris and coarse sediment. There are no existing secondary or tertiary treatment measures in the catchment (such as ponds, wetlands or biofiltration).

A Model for Urban Stormwater Improvement Conceptualisation (MUSIC) model was established to quantify the existing water cycle behaviour and estimate the existing pollutant loading from the Broadmeadow Precinct and upstream catchment. This aided in understanding the degree of treatment provided by the existing GPTs. Results of this base case modelling revealed the estimate the treatment efficiency of existing gross pollutant traps, noting that these do not have a significant impact on overall catchment water quality.

Flood Impact and Risk Assessment

Flood Mitigation Strategy

A flood mitigation strategy has been developed to address the flood risk and impacts associated with the development comprising:

- Flood modification measures (to reduce flood risk)
- Planning and development controls (to respond to flood risk)

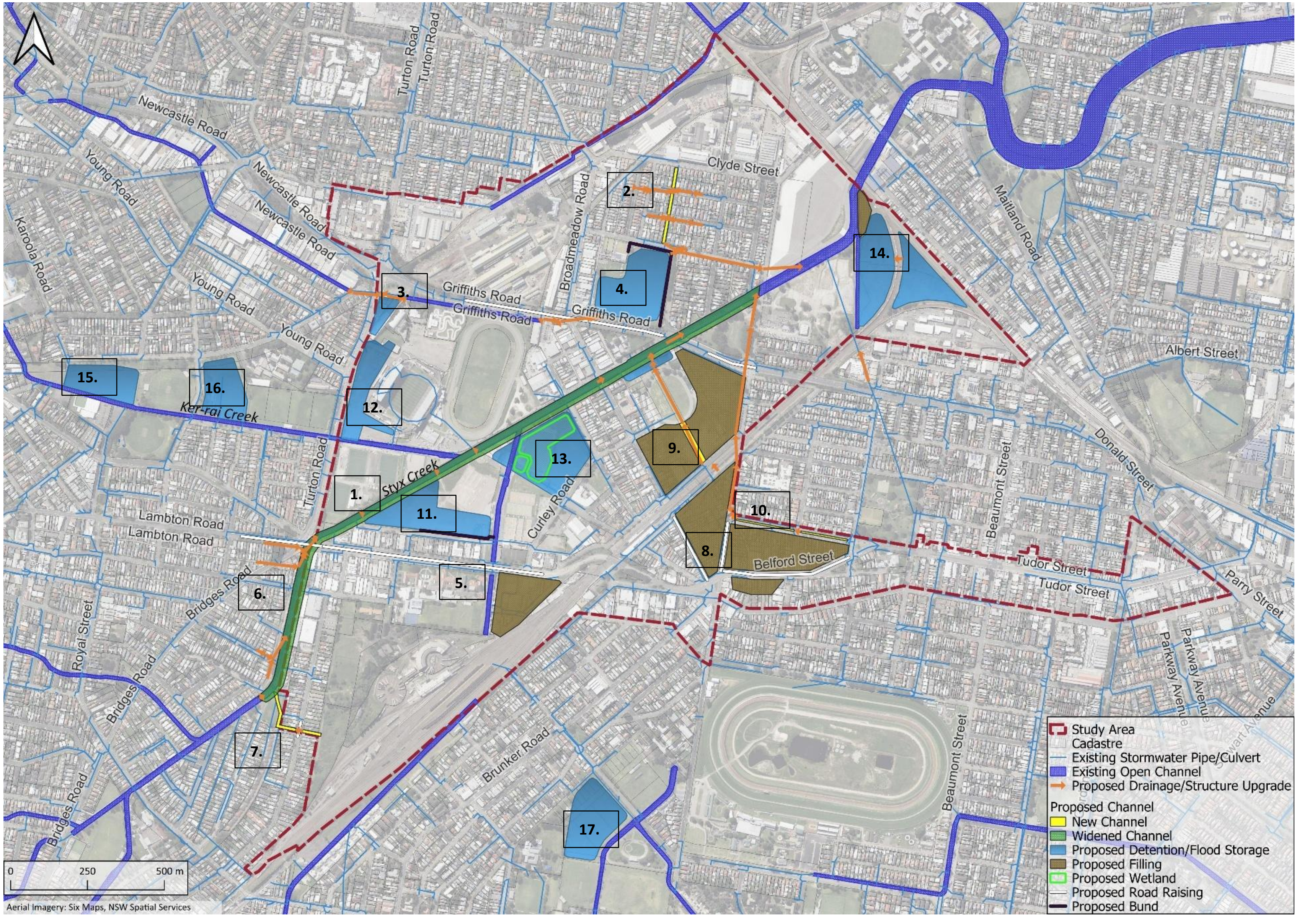
- An education initiative in relation to emergency response (to manage residual flood risk).

The flood modification measures required to sufficiently manage Precinct flooding and impacts are extensive and include the following engineering works:

- ***Upgrade*** of channels and drainage lines that are critical for the conveyance of floodwaters through the Precinct. This includes the widening and partial naturalisation of Styx Creek.
- ***Diverting*** breakout flows back to Styx Creek at the upstream extent of the Precinct.
- ***Raising*** Lambton Road and Griffiths Road to provide flood immunity to ensure there is only a 1% chance of exceedance in any one year of floodwaters inundating the road level in 2050. This will improve emergency services access to the Precinct and reduce isolation time in an extreme event (such as the PMF).
- ***Filling*** of lower lying areas and upgrading downstream drainage lines to reduce the duration of inundation in a PMF event.
- ***Excavation*** of select public and private open space areas to provide flood storage/detention to offset increases in flows along Styx Creek. This includes a number of areas upstream of the Precinct where lowering of ground levels was found to be effective at reducing downstream flows.

The locations of flood modification measures are summarised in the following map.

Further detail of each measure outlined in **Section 6.1**.



Flood Modification Measures Overview

Post-Development Scenario Flood Modelling

The base case flood model from the Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023) was updated to incorporate proposed land-use changes and flood mitigation measures.

Results of the post-development flood model revealed that the proposed mitigation measures provide flood immunity up to a 1% chance of exceedance in any one year of floodwaters in 2050 in areas where rezoning to more densely populated land uses is proposed. There are two exceptions:

- Broadmeadow Locomotive Precinct – results show shallow flooding would occur in the 1%AEP (or greater) over a number of residential lots. However, higher resolution modelling undertaken as part of the separate site-specific assessment *Flood Impact Assessment – Broadmeadow Locomotive Precinct* (BMT, 2023) indicates that these lots are flood free in an equivalent event. Mitigation measures included in the assessment included and upgraded pit and pipe network and earthworks to direct overland flow paths.
- Council depot site on the corner of Griffiths and Turton Road – it is recommended that the existing land zoning is retained.

Flood impact mapping generally shows either nil impact or a reduction in flood levels on private property external to the Precinct for events ranging from the 10% AEP up to and including the 1% AEP in 2050.

Minor flood level increases (in the 2% AEP) immediately downstream of the Precinct could be eliminated with minor refinements to the proposed flood/detention storage outlet controls. Minor off-site increases in flood levels are also observed in a number of other public and privately owned blocks near Throsby Creek and Maitland Road; however, these impacts can be attributed to the flood model's local inflow methodology rather than floodplain modifications. In rare and extreme events, such as the PMF, increases in flood levels would not result in any significant increase in the risk to life.

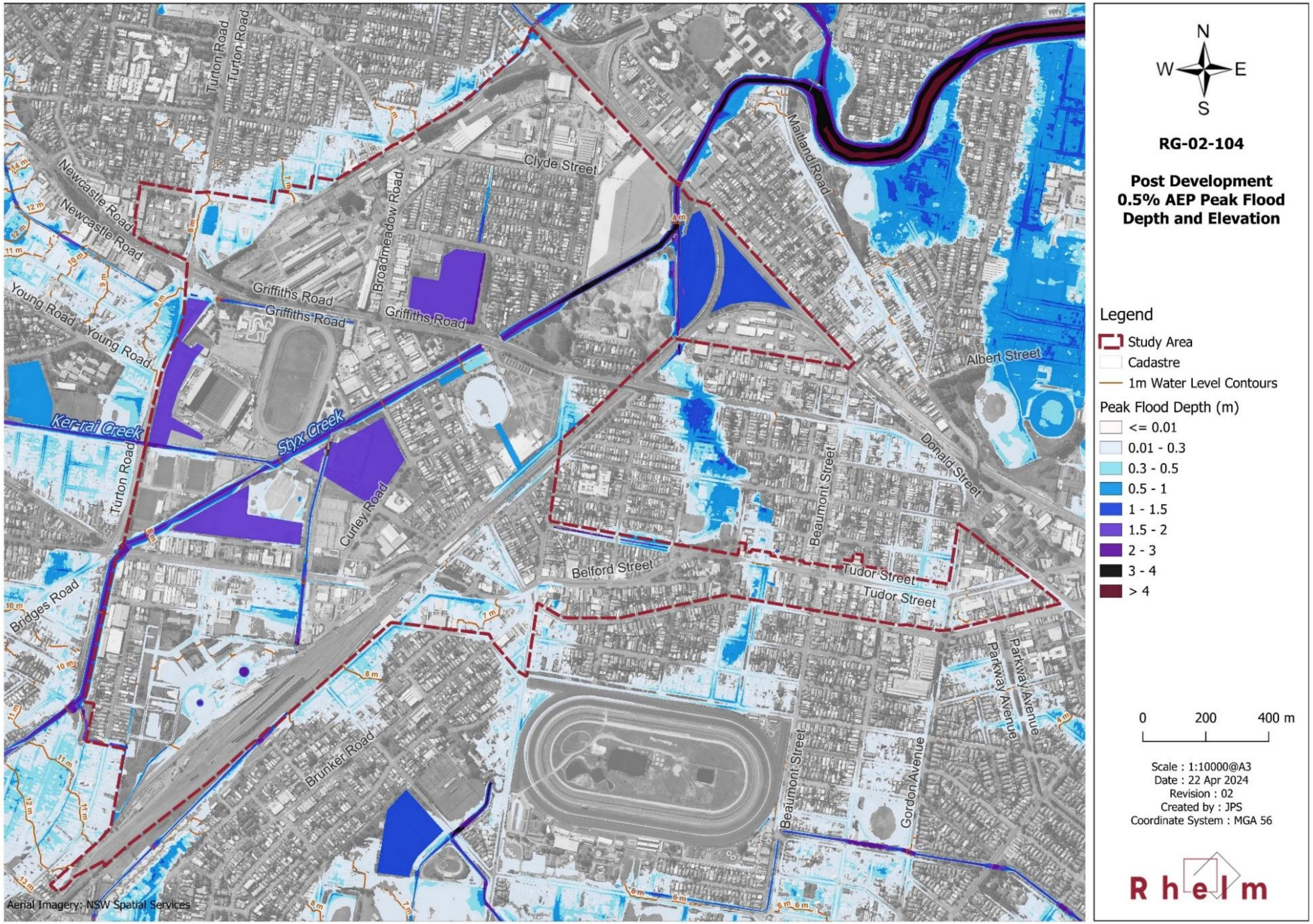
The assessments of the proposed rezoning demonstrate no negative flood impacts external to the Precinct, and an effective decrease of flood risk across the Precinct with positive impacts to peak flood depths along emergency access routes and within private properties.

The map below shows the post-development peak flood depths and elevations for the 1% AEP in 2050 event.

Staging and First Moves

A preliminary assessment was undertaken to identify the flood mitigation infrastructure required with each stage of the Precinct development. This included modelling of the 'first moves' stages to assess the flood impacts associated with this initial staging and corresponding flood mitigation infrastructure. Key findings of this assessment include:

- The majority of flood mitigation measures will need to be constructed during Stage 1 of the Precinct rezoning/development
- The first moves also require a significant portion of mitigation works to address adverse flood impacts
- The Newcastle Racecourse detention basin option is beneficial in terms of reducing the number of required flood storage/detention basins, particularly in the first moves stages.



Post-Development Conditions Peak Flood Depth and Elevation (0.5%AEP Event)

Emergency Management

The flash flooding nature of the Styx Creek catchment does not allow for sufficient warning or response time for the safe evacuation of the Precinct in a severe rainfall event. As such, a shelter in place strategy is proposed for the Precinct.

For a shelter in place strategy to be considered appropriate, residents seeking refuge must not be isolated for prolonged periods of time. The *Draft Shelter-in-place Guideline* (DPE, 2023) nominates a maximum 6-hour duration of inundation threshold in flash flood environments for the use of shelter in place strategies.

The proposed flood modification measures limit the PMF duration of inundation (for flood hazard exceeding a H1 classification) to less than 6 hours across areas where the proposed rezoning will increase population density in the floodplain. The duration of inundation is also reduced to less than 6 hours along the critical emergency services access routes of Griffiths Road and Lambton Road. For the remaining areas within the Precinct, which are not proposed to be rezoned, and for the surrounding region, the proposed flood modification works will reduce the duration of inundation in the PMF event from that under existing conditions.

Flood Planning Area

The 1% AEP in 2050 has been proposed as the defined flood event for Precinct flood planning purposes. The 0.5% AEP is used as a proxy rainfall event for the 1% AEP event in 2050, with 0.45m applied to the downstream boundary conditions to account for sea level rise.

The site flood planning area has been defined based on 1% AEP in 2050 flood levels with a 0.5m freeboard allowance and limited to Probable Maximum Flood (PMF) extents.

Water Cycle Management Assessment

The proposed approach to water cycle management involves:

- ***Lot-scale strategies*** – the retention of Council's on-lot volumetric discharge controls and pollutant reduction targets stipulated in Section C4 of Council's DCP
- ***New regional stormwater treatment features*** – to improve overall catchment water quality outcomes compared to existing conditions. Proposed regional interventions include:
  - Upgrades to the GPT adjacent to the Westpac Rescue Helicopter site, and
  - a constructed wetland in the north-western portion of Magic Park, within the broader flood storage/open space area at this location.

The base case MUSIC model was updated to reflect the post-development land use zoning and incorporate the proposed regional wetland. Results of the post-development MUSIC model showed slight water quality improvements compared to existing conditions, with suspended solids and nutrient levels in the order of 2-7% lower than existing conditions from an overall catchment perspective. These levels will be further reduced when coupled with the proposed on-lot treatment in accordance with the Newcastle DCP 2023.

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Appendices

Acronyms and Abbreviations

1D	One-Dimensional
2D	Two- Dimensional
AHD	Australian Height Datum
AEP	Annual Exceedance Probability
AIDR	Australian Institute for Disaster Resilience
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
CBD	Central Business District
CoN	City of Newcastle Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPHI	Department of Planning, Housing and Infrastructure
FPL	Flood Planning Level
ha	Hectares
LEP	Local Environment Plan
LGA	Local Government Area
m^2	Square metres
m^3	Cubic metres
m/s	Metres per second
m^3/s	Cubic metres per second
m AHD	metres to Australian Height Datum
mm	Millimetres
m/s	Metres per second
NorBE	Neutral or Beneficial Effect
NSW	New South Wales
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service
TAHE	Transport Asset Holding Entity
TfNSW	Transport for New South Wales

1 Introduction

Broadmeadow was identified by the NSW Government as a 'Regionally Significant Growth Area' in the NSW Government's Hunter Region Plan 2041 with Broadmeadow providing a strategic opportunity for sustainable growth.

Due to the significance of the precinct it was determined that a coordinated and strategic approach was required, and a Place Strategy was to be prepared for the whole Precinct. As such in December 2022, the NSW Minister for Planning and Minister for Housing announced Broadmeadow as a part of the Planning for Growth New Planning Proposal (NPP) Program.

Housing the Hunter: a plan for renewal at Broadmeadow is the coordinated approach for the Broadmeadow Precinct, which includes the City of Newcastle (Council) led Place Strategy and the Department of Planning, Housing and Infrastructure (DPHI) led first move rezoning.

Rhelm have been commissioned by DPHI to provide technical advice and analysis on the Place Strategy and first move rezoning sites for the Broadmeadow redevelopment area.

This report considers the Emerging Scenario with respect to flooding and water cycle management. The report is structured as follows:

- Review of Previous Studies and Reports (**Section 2**)
- Planning, Policy and Guidelines Review (**Section 3**)
- Baseline Analysis (**Section 4**)
- Emerging Scenario (**Section 5**)
- Flood Impact and Risk Assessment (**Section 6**)
- Water Cycle Management Assessment (**Section 7**)
- Conclusion and Recommendations (**Section 8**).

1.1 Study Area

The study area is 313 ha and largely centred in Broadmeadow, NSW, approximately 3 km west of the Newcastle CBD. **Figure 1-1** outlines the extent of the Precinct in the context of the main watercourses in the locality.

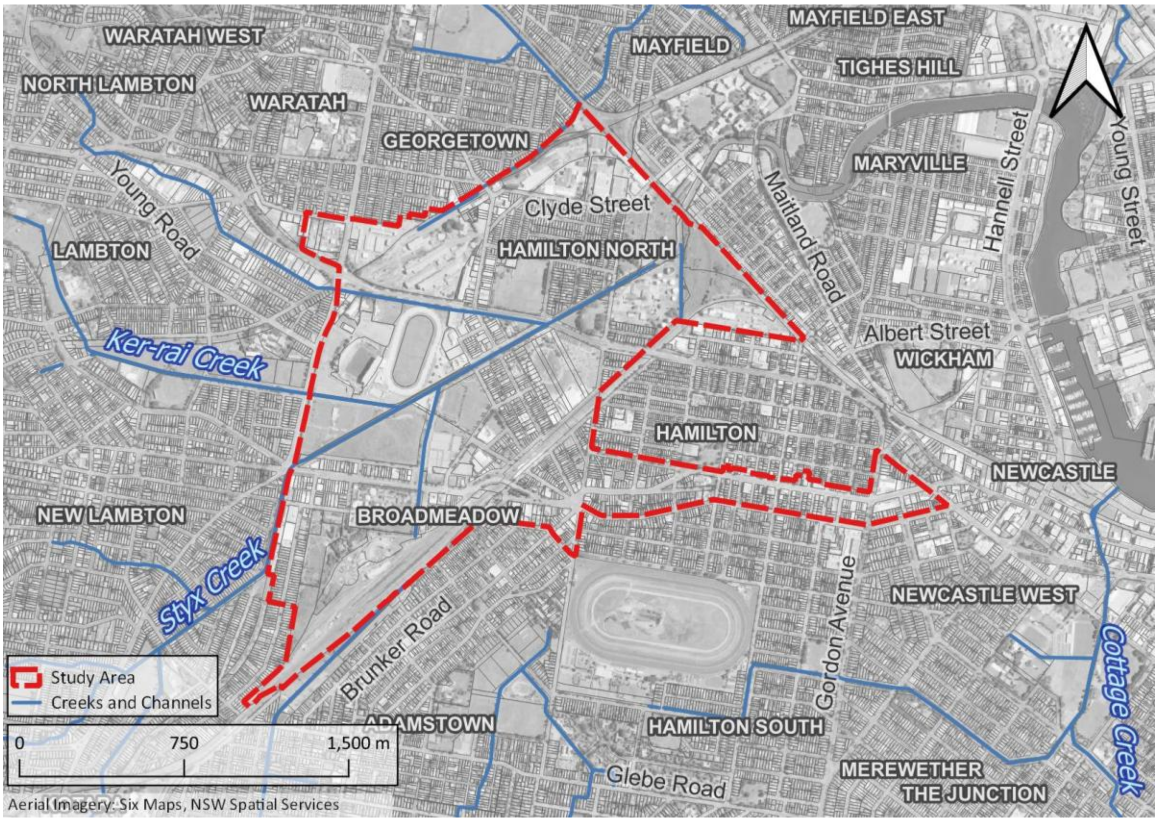

Figure 1-1. Study Area

Current land uses include a mix of low density residential, industrial, commercial, institutional (schools and regional sport, recreation and entertainment facilities), as well as major rail and vehicle transport routes.

1.2 Existing Surface Water Conditions and Infrastructure

The Broadmeadow redevelopment area contains Styx Creek and a significant quantity of existing stormwater drainage infrastructure. This includes a number of concrete-lined open channels (the most significant being Styx Creek), cross drainage culverts, and pit and pipe networks to collect and convey runoff to the open channels. The location of existing drainage infrastructure is shown in **Figure 1-2**. Stormwater assets are owned and maintained by both Council and the Hunter Water Corporation (HWC), with generally Council assets including the pit and pipe network stormwater network and HWC assets consisting of the open channels.

Styx Creek is a tributary of Throsby Creek, which is a tributary of the Hunter River. Styx Creek is tidal in its lower reaches, to approximately the centre of the Precinct.

The area is relatively flat and low lying, being located in what was once alluvial floodplain and marshland, prior to European settlement.

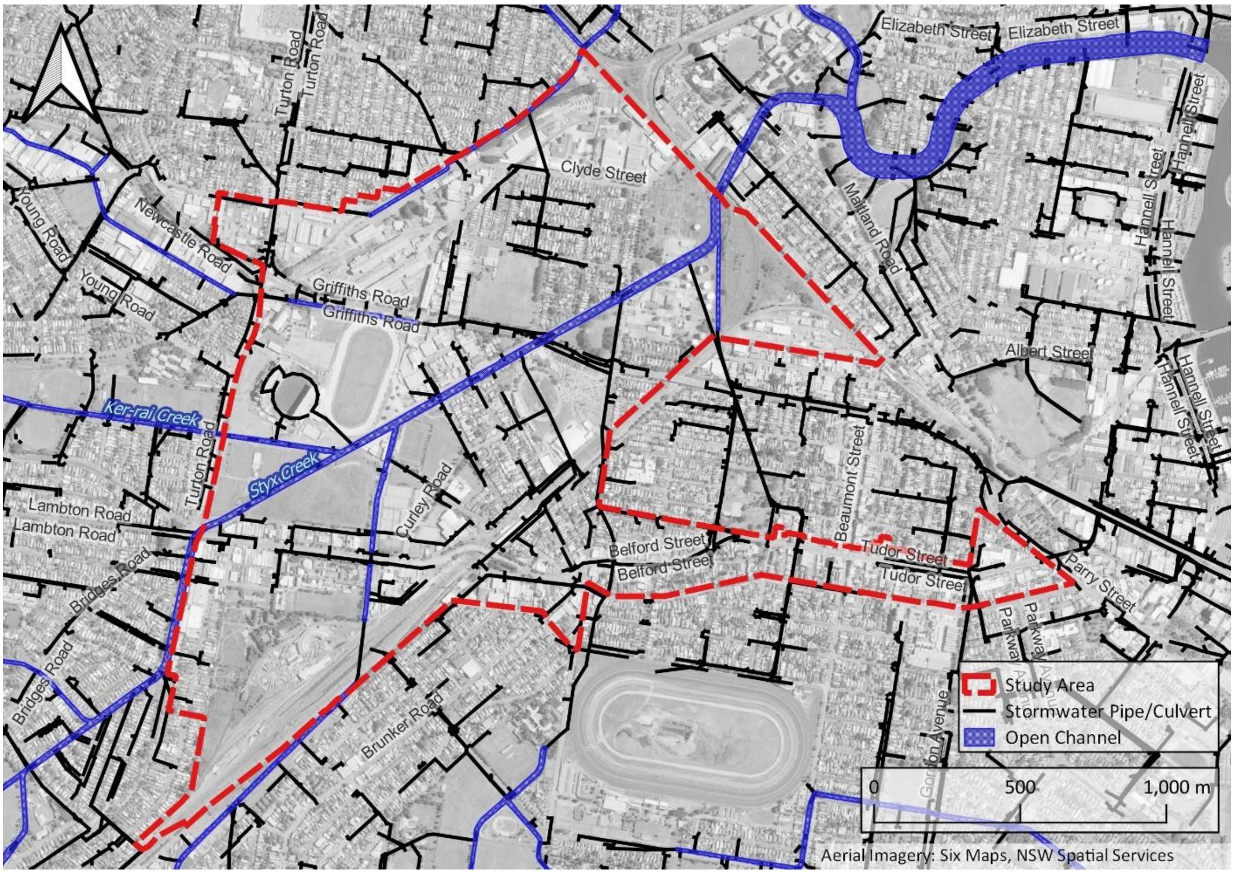

Figure 1-2. Existing Stormwater Drainage

2 Review of Previous Studies and Reports

The following section highlights reports, studies and plans most pertinent to this flooding and water cycle management assessment.

2.1 Newcastle Stormwater Management Plan (City of Newcastle Council, 2005)

The *Newcastle Stormwater Management Plan* identifies stormwater issues observed within the region, defines catchment management objectives and outlines a plan for the management of stormwater quality and quantity in the Newcastle LGA.

Of particular relevance to the study area is the observation of litter accumulation and sediment deposition in Throsby Creek which is likely indicative of excessive pollutant loading from Styx Creek, its major tributary. Although the final version of this study was published approximately nearly 20 years ago, there does not appear to have been significant structural interventions in the years since publication and similar issues likely remain relevant.

Key management measures recommended in this Plan include:

- Education programs for the community and asset managers;
- Water cycle management policy implementation;
- Development of stormwater management standards;
- Auditing and maintenance programs;
- At source gross pollutant control program for pollutant 'hotspots';
- Investigation of riparian corridor revegetation; and
- Street cleaning programs.

2.2 Newcastle City-Wide Floodplain Risk Management Study and Plan (BMT WBM, 2012)

The *Newcastle City-wide Floodplain Risk Management Study and Plan* outlines the overall risks of flooding to the Newcastle LGA covering flooding from catchment rainfall events, ocean storms and Hunter River flooding. It summarises historic flooding events and their impacts as well estimating the impact of design flood events.

There is an overarching acknowledgement that flooding in Newcastle is widespread, and many areas are flood prone. Up to 21,000 properties are flooded in the PMF out of the approximately 58,000 developed properties in the City of Newcastle. This was primarily caused during the development of the city when natural flow paths were not used for alignment of the concrete open channels and, furthermore, those channels were sized using outdated methodologies. As the catchments of the local creeks and channels became developed, the introduction of paved surfaces and roofs compounded this problem.

The City-Wide Plan (BMT WBM, 2012) also made efforts to identify any structural flood mitigation measures which would alleviate flooding in some areas; however, these were aimed at providing better flood behaviour outcomes for local areas as no large-scale works would be possible to reduce flooding on a suburb or precinct scale. No structural flood mitigation measures were identified in Broadmeadow.

The majority of recommendations for both immediate flood risk reduction and longer-term strategies included these overarching principles:

- Community education;
- Improve flood prediction and warning systems;

- Implement new planning controls;
- Update emergency management plans; and
- House raising, voluntary purchases, and building strengthening.

This document is an excellent source for understanding flood risk in Newcastle, with the following information pertinent to assisting the redevelopment of Broadmeadow:

- Risk to life can occur for those in flood prone properties who stay in their home during an extreme event; however, the risk is likely to be greater for people evacuating in vehicles as roadways are subject to higher velocity flood waters can result in vehicles being washed away.
- Increasing channel capacities (by expansion) does not have a significant positive large-scale effect on flood behaviour as the surrounding terrain is generally flat and relies on stormwater drainage systems to convey flows to the channels (i.e. the water cannot reach the channels fast enough).
- Community education and warning will be crucial in keeping people safe during flood events.
- Broadmeadow experienced some of the worst flooding during the June 2007 event as it lies at the confluence of a number of channels.
- While a PMF event will cause massive widespread damage across the Styx Creek floodplain, even in smaller events such as the 1% AEP, Broadmeadow is still significantly impacted.
- Dwellings (future and existing) should have elevated flood-free refuge above the PMF level and be structurally sound to withstand flood forces for all events up to and including the PMF.

2.3 Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023)

The *Throsby, Styx and Cottage Creek Flood Study* is the most recent definition for flood behaviour in the Throsby, Styx and Cottage Creek catchments. This study has been adopted by council with the associated flood model suitable for use in assessing the Precinct. Undertaken as part of the NSW Floodplain Management Program and in accordance with the Floodplain Risk Management Manual (DPE, 2023), the Flood Study has:

- Reviewed all available data;
- Established a flood model which can accurately reproduce flood behaviour for the June 2007, February 1990 and April 1988 historic flood events;
- Produced design event flood behaviour for events ranging from the 10% AEP up to the PMF;
- Been publicly exhibited as a Draft Flood Study; and
- Been finalised following review of community responses.

This study, and the associated flood model established with it, has been used to understand design event flood behaviour and quantify the effects on flood behaviour as part of the redevelopment of the Precinct.

2.4 City of Newcastle Flood Emergency Sub Plan (SES, 2013)

The *City of Newcastle Flood Emergency Sub Plan* covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the City of Newcastle Local Government Area. It covers operations for all levels of flooding within the council area.

For the redevelopment of Broadmeadow, this document will assist in identifying emergency evacuation and access procedures, as well as recovery plans following a flood events.

2.5 Flood Impact Assessment – Broadmeadow Locomotive Precinct (BMT, 2023)

Transport for NSW (TfNSW) and the Transport Asset Holding Entity (TAHE) commissioned BMT to undertake a Flood Impact Assessment in support of a planning proposal to re-zone the Locomotive Depot site, located in the southern corner of the Precinct.

Flood modelling data for this assessment was provided by BMT and incorporated into the post-development Precinct flood model (refer **Section 6.2**).

2.6 Redevelopment of Hunter Park Precinct Strategic Business Case – Hydrology, Overland Flow & Flood Modelling Desktop Study (Mott MacDonald, 2022)

Venues NSW commissioned Mott MacDonald to undertake a hydrology and flooding assessment in support of a business case for the proposed redevelopment of Hunter Park, located towards the centre of the Precinct.

The approach to managing flooding in this portion of the Precinct was considered in the development of the proposed flood mitigation strategy (refer **Section 6.1**).

3 Planning, Policy and Guidelines Review

Within the Broadmeadow Precinct, development is currently controlled primarily through the *Newcastle Local Environmental Plan* 2012 (LEP 2012) and *Development Control Plan* 2023 (DCP 2023). The LEP is an environmental planning instrument which designates land uses and development in the study area, while the DCP regulates development in the relevant zones with specific guidelines and parameters.

The flood-related planning and policy review for the Broadmeadow Precinct planning is structured as follows:

Section 3.1 outlines the purpose of the planning, policy and guidelines review for the Broadmeadow Precinct planning.

Section 3.2 summarises the flood and water cycle management related Council planning instruments and guidelines.

Section 3.3 reviews the findings and recommendations of the NSW Flood Inquiry and details any potential implications related to the Precinct.

Note that there are also numerous environmental planning instruments that have site specific or state-wide application of relevance to the site. This review does not seek to address those instruments.

3.1 Purpose

The purpose of the planning and policy review is to:

- Summarise the existing flood-related planning provisions that apply to the Precinct;
- Assess the adequacy, based on knowledge of existing flood behaviour and the latest flood-related planning guidance;
- Review the findings of the NSW Flood Inquiry (August 2022) and summarise any implications related to the Broadmeadow Precinct planning; and
- Determine what additional flood-related development controls may be warranted in a future precinct DCP.

This review does not specifically deal with matters related to building construction (such as the National Construction Code, which includes the Building Code of Australia (BCA), both of which are updated every three years by the Australian Building Codes Board). However, it is important to note that these types of controls are sometimes called or referenced in planning controls and therefore their content and direction are of relevance. In this regard, how they are applied is directed under the NSW Planning System via numerous mechanisms but primarily via Building System Circulars issued by the Department of Planning, Housing and Infrastructure. The most relevant circular is BS 13-004, dated 16 July 2013 entitled *The NSW Planning System and the Building Code of Australia 2013: Construction of Buildings in Flood Hazard Areas*. Importantly the BCA deals with the concept of the 'defined flood event' (DFE) and imposes minimum a construction standard across Australia for specified building classifications 'flood hazard areas' (FHA) up to the DFE. These requirements should be referenced when developing appropriate recommendations for policy and planning approaches within the Precinct.

3.2 Council Planning Instruments and Guidelines

3.2.1 Newcastle Local Environment Plan 2012

The Newcastle Local Environmental Plan 2012 (LEP 2012) sets the direction for land use and development in the study area. It determines what can be built, where it can be built and what activities can occur on land.

The Newcastle LEP 2012 is based on a standard format used by all Councils in NSW and can be viewed on the NSW legislation website (https://legislation.nsw.gov.au/view/html/inforce/current/epi-2012-0255). The most recent update to the LEP 2012 as of the writing of this assessment is 4 March 2024.

The standard flood planning clauses are included in Section 5.21. There are no clauses in the Newcastle LEP 2012 that directly stipulate water cycle management objectives or requirements.

5.21 Flood planning

1) The objectives of this clause are as follows—

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,

(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,

(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—

(a) is compatible with the flood function and behaviour on the land, and

(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties,

(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and

(d) incorporates appropriate measures to manage risk to life in the event of a flood

(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters—

(a) the impact of the development on projected changes to flood behaviour as a result of climate change,

(b) the intended design and scale of buildings resulting from the development,

(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,

(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause—

***Considering Flooding in Land Use Planning Guideline** means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.*

***flood planning area** has the same meaning as it has in the Flood Risk Management Manual.*

Flood Risk Management Manual *means the Flood Risk Management Manual, ISBN 978-1-923076-17-4, published by the NSW Government in June 2023 .*

In 2021, DPE invited Councils in NSW to self-nominate to include the 'special flood considerations' clause within their LEPs. City of Newcastle nominated to include the clause and this was incorporated in the LEP in late 2023.

The special flood considerations clause is reproduced below.

5.22 Special flood considerations

The changes will apply additional planning controls to land at risk of flooding. This will help reduce the extent of property damage and potential loss of life and build greater resilience into our communities.

The standard special flood considerations clauses are:

(1) The objectives of this clause are as follows—

(a) to enable the safe occupation and evacuation of people subject to flooding,

(b) to ensure development on land is compatible with the land's flood behaviour in the event of a flood,

(c) to avoid adverse or cumulative impacts on flood behaviour,

(d) to protect the operational capacity of emergency response facilities and critical infrastructure during flood events,

(e) to avoid adverse effects of hazardous development on the environment during flood events.

(2) This clause applies to—

(a) for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and

(b) for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may—

(i) cause a particular risk to life, and

(ii) require the evacuation of people or other safety considerations.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—

(a) will not affect the safe occupation and efficient evacuation of people in the event of a flood, and

(b) incorporates appropriate measures to manage risk to life in the evenIf a flood, and

(c) will not adversely affect the environment in the event of a flood.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause—

Considering Flooding in Land Use Planning Guideline*—see clause 5.21(5).*

flood planning area*—see clause 5.21(5).*

Flood Risk Management Manual*—see clause 5.21(5).*

probable maximum flood *has the same meaning as it has in the Floodplain Development Manual.*

sensitive and hazardous development *means development for the following purposes—*

(a) boarding houses,

(b) caravan parks,

(c) correctional centres,

(d) early education and care facilities,

(e) eco-tourist facilities,

(f) educational establishments,

(g) emergency services facilities,

(h) group homes,

(i) hazardous industries,

(j) hazardous storage establishments,

(k) hospitals,

(l) hostels,

(m) information and education facilities,

(n) respite day care centres,

(o) seniors housing,

(p) sewerage systems,

(q) tourist and visitor accommodation,

(r) water supply systems.

3.2.2 Newcastle DCP 2023

The Newcastle DCP 2023 provides detailed planning and design guidelines to support the planning controls in the Newcastle LEP 2012.

Controls relating to flooding and water cycle management are summarised in the following sections.

3.2.2.1 Section B1(b) Flood Management

Flood-related development controls are stipulated in Section B1(b) of the Newcastle DCP 2023. Controls relevant to the Broadmeadow Precinct are reproduced below.

6.0 Floodways

Objectives

1. Retain floodways in a condition capable for the conveyance of essential flood flow.

Controls

C-1. No building or structure erected and no land filled by way of the deposition of any material within any area identified as a floodway except for minor alterations to ground levels which do not significantly alter the fundamental flow pattern for:

(a) roads

(b) parking

(c) below ground structures

(d) landscaping.

C-2. Where dividing fences across floodways are unavoidable, they are constructed only of open type fencing that does not restrict the flow of flood waters and are resistant to blockage. New development shall be designed to avoid fences in floodway

7.0 Flood Storge Areas

Objectives

1. Protect flood storage areas to provide storage of floodwaters to ensure that other areas are not significantly worse off due to development of the site.

Controls

C-1. Not more than 20% of the area of any development site in a flood storage area is filled. The remaining 80% is generally developed allowing for underfloor storage of floodwater by the use of suspended floor techniques such as pier and beam construction.

Where a development is proposing to build over more than 20% of the site area, the portion of the structure being suspended is to have a floor level at the FPL as a minimum. As part of the structure's design, it must allow water to flow freely into and out of the underfloor area and must not be restricted by solid cladding or similar around the perimeter of the structure below the floor level.

C-2. Where it is proposed to fill development sites, the fill does not impede the flow of ordinary drainage from neighbouring properties, including overland flow.

8.0 Management of Risk to Property

Objectives

1. Manage risks to property up to an acceptable level of risk (the flood planning level).

Controls

C-1. Floor levels of all occupiable rooms of all buildings are not set lower than the FPL.

C-2. Garage floor levels are no lower than the 1% 2050 Annual Exceedance Probability Event. However, it is recognised that in some circumstances this may be impractical due to vehicular access constraints. In these cases, garage floor levels are as high as practicable.

C-3. Basement garages may be acceptable where all potential water entry points are at or above the probable maximum flood (PMF), excepting that vehicular entry points can be at the FPL. In these cases, explicit points of refuge are accessible from the carpark in accordance with the provisions for risk to life set out below.

C-4. Electrical fixtures such as power points, light fittings and switches are sited above the FPL unless they are on a separate circuit (with earth leakage protection) to the rest of the building.

C-5. Swimming pools are to be located to ensure they are not inundated from minor flooding events. Electrical connections and fixtures around swimming pools are to be sited at the FPL.

C-6. Where parts of the building are proposed below the flood planning level, they are constructed of water-resistant materials.

C-7. Areas where cars, vans and trailers are parked, displayed or stored are not located in areas subject to property hazard of P1 or higher. Containers, bins, hoppers and other large floatable objects also are not stored in these areas. Heavy vehicle parking areas are not located in areas subject to property hazard P1 or P2 categories.

C-8. Timber framed, light steel construction, cavity brickwork and other conventional domestic building materials are generally suitable forms of construction where the property hazard is P1 to P4.

C-9. Property hazard of P5 is generally unsuitable for building construction and building is discouraged from these areas. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.

C-10. Property hazard of P6 is unsuitable for any type of building construction.

9.0 Management of Potential Risk to Life

Objectives

1. Only permit new development or redevelopment where the full potential risk to life from flooding can be managed for all floods up to and including the PMF.

Controls

C-1. Risk to life category L5 is generally unsuitable for building construction and building is discouraged from these areas. Reliable safe escape to high ground is likely not possible and normal building construction would likely suffer structural failure from the force of floodwaters, so that any people seeking refuge in the building would likely perish. Where building is necessary, the structure is certified by a practising structural engineer to withstand the hydraulic loads (including debris) induced by the flood waters.

C-2. Risk to life category of L6 is unsuitable for any type of building construction.

C-3. Islands. The formation of islands in the floodplain during a flood is a potentially dangerous situation, especially when floods larger than the FPL totally inundate the island for an extended period. Development of such land is considered with great care.

C-4. On-site refuge. On-site refuge is to be provided for all development where the risk to life category is L3 or higher unless:

(a) the proposed development is less than 40m from the perimeter of the PMF extent and the higher ground is accessible, or

(b) the proposed use is defined as commercial premises or industry in which case onsite refuge is only required where the hazard category is L4 or high.

C-5. Standards for on-site refuge. Where on-site refuge is required for a development, it should comply with the following minimum standards:

(a) the minimum on-site refuge level is the level of the PMF. On-site refuges are designed to cater

for the number of people reasonably expected on the development site and are provided with emergency lighting *(b) on-site refuges are of a construction type able to withstand the effects of flooding. Design certification by a practising structural engineer that the building is able to withstand the hydraulic loading due to flooding (at the PMF).*

3.2.2.2 Section C4 Stormwater

Objectives and development controls relating to stormwater/water cycle management are stipulated in Section C4 of the Newcastle DCP 2023.

The water cycle management objectives are listed below:

<u>General Stormwater Management Provisions</u>

1. Ensure stormwater is mitigated and controlled to minimise nuisance, including to adjoining properties, and public roadways and other spaces

<u>Water Quantity</u>

2. Maximise the reusability of stormwater through appropriate storage solutions.

3. Ensure that post development runoff matches the natural water runoff regime as closely as possible.

4. Establish stormwater management requirements for development in coastal wetland catchments and minimise impacts of stormwater run-off on coastal wetlands.

<u>Water Quality</u>

5. Ensure an appropriate quality of water enters waterways.

6. Minimise the potential impacts of development and associated activities on the aesthetics, recreational and ecological values of receiving waters.

7. Prevent pollutants such as litter, sediment, nutrients and oils from entering waterways.

8. Ensure stormwater treatment measures are designed appropriately to protect property, life and maximise infrastructure performance and useful life.

<u>Onsite Controls</u>

9. Ensure onsite controls are considered and incorporated early in the development to ensure a catchment sensitive, holistic, integrated and economical design.

10. Incorporate water sensitive urban design elements into the urban landscape for ecological enhancement.

11. Ensure public and shared private infrastructure is delivered at an appropriate standard for easy maintenance and allowing access for maintenance to occur.

<u>Stormwater Discharge</u>

12. Ensure overflow does not adversely affect the subject site and other properties or waterways by way of intensification, concentration or inappropriate disposal across property boundaries.

<u>Existing Drainage Systems, Easements and Waterfront Land</u>

13. Ensure appropriate easements are provided over drainage systems on private properties.

14. Ensure easements are unimpeded by development for maintenance purposes and high flow overland flow paths.

15. Ensure development containing or adjacent to waterfront land maintains or rehabilitates the environmental values and drainage functions of riparian corridors.

16. Ensure discharge points to waterways and/or waterway crossings do not increase the risk of erosion, blockage or flooding both onsite and offsite.

Key controls relevant to the Broadmeadow Precinct water cycle management strategy are summarised in **Table 3-1**. It should be noted that a site-specific DCP could be considered for the Precinct that may include alternate or additional controls to achieve Precinct-specific objectives.

Table 3-1. Relevant Water Cycle Management Related Controls from Newcastle DCP 2023

Control	Relevance to Broadmeadow Precinct Planning
8.0 General Stormwater Management Provisions C-6. Manage runoff generated by more intense rainfall to not compromise downstream drainage systems beyond their design criteria. C-7. Runoff from development up to and including the 5% AEP shall be collected and drained underground. Public drainage (minor system) has a design capacity of the 10% AEP and connections from private development shall be made subject to the 10% AEP hydraulic grade line of the public drainage being lower than the property drainage system. C-8. Drain runoff from the development up to the 1% AEP event to the major drainage system so it poses nil adverse impact to neighbouring properties. C-9. Development ensures that peak runoff from the site for all events is not greater than the natural drainage conditions of the site. C-10. Development sites are to accommodate natural overland flow from adjacent properties, and where these flows continue downstream to other adjacent properties they are not to be concentrated.	The water cycle management strategy considers both lot scale and regional stormwater detention to limit post-development flows to pre-development levels. The flood mitigation strategy includes the upgrade of key stormwater drainage lines to achieve Precinct flood objectives. This does not consider smaller stormwater lines (less than 750mm in diameter) and private drainage. .
9.0 Water Quantity C-1. Storage requirements are outlined in Table C4.01 for development outside the coastal wetland catchment. Storage requirements for development in the coastal wetland catchment are outlined in Table C4.02. C-3.Storage can be in a detention tank or other control, as listed in the onsite development controls. Where a detention tank is used, an orifice (or pipe) can be placed at the base of the detention portion of the tank to control flows, sized as follows: a. 65mm orifice for detention tanks up to 30 m^3 b. 100mm orifice for detention tanks larger than 30m^3 C-4. Alterations and additions within the existing building footprint, such as building a second floor, do not require additional onsite controls. However, in the case of a total redevelopment of that footprint, the existing footprint will not be credited, and the development must achieve the full storage requirements.	It is proposed that Council's lot scale storage and runoff controls are maintained across the Precinct to assist in achieving stormwater and sustainability objectives.

Control	Relevance to Broadmeadow Precinct Planning
C-5. Where there is a change in the impervious area of an existing site as a result of a full redevelopment, the entire predeveloped site is to be considered in natural condition in regard to impervious areas for design purposes. C-9.For Type 3 development sites, it will be necessary to undertake a more rigorous hydrologic and hydraulic assessment to demonstrate that the flooding and runoff regimes are being satisfied in accordance with the development controls and the Stormwater and Water Efficiency for Development Technical Manual. Detention systems shall be designed to ensure post development flows do not exceed natural flows during the following events: 50% AEP, 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP. C-10.Where a large-scale storage solution, such as on-site detention is provided as part of the subdivision, individual tank storage volumes may be reduced by a commensurate amount.	
<u>10.0 Water Quality</u> C-3. Type 2 and 3 developments shall meet the targets outlined in Table C4.04 *(and reproduced below).* *Total Suspended Solids - 85% reduction in the average annual load of Total Suspended Solids.* *Total Nitrogen - 45% reduction in the average annual load of Total Nitrogen.* *Phosphorous - 65% reduction in the average annual load–of Total Phosphorus.* *Gross Pollutants - 90% reduction in the average annual load of Gross Pollutants (>5mm).* *Hydrocarbons - 100% removal.* C-4. Stormwater treatment measures are located and configured to maximise the impervious area that is treated. Devices are to be located within the property boundary. C-5.Stormwater treatment measures must be able to bypass flows that are in excess of the design discharge in a controlled manner and are engineered to connect to suitable downstream discharge points with negligible concentrated flows resulting from overtopping or blockage of the device.	The proposed approach to water quality management involves maintaining Council's on-lot development water quality targets and incorporating regional interventions at select locations to improve overall catchment water quality outcomes. The Broadmeadow catchment does not drain to a listed coastal management wetland and thus the wetting and drying hydrology targets are not applicable.
<u>11.0 Onsite Controls</u> C-3.Development that creates public assets is to comply with the development controls and be carried out in accordance with the requirements for public assets as outlined in the Stormwater and Water Efficiency for Development Technical Manual. Public Assets are to be designed in accordance with CN's Standard Drawings. C-4.Provide site specific maintenance manuals for onsite controls for development sites larger than 5,000m^2, or where public assets or a private shared asset is created via strata or community title subdivision. Manuals shall address maintenance issues including routine monitoring and maintenance and associated system components (such as vegetation, subsurface drainage, filter material, flush outs, etc) that could impact device performance. Carry our	It is proposed that Council's lot scale onsite controls are maintained across the Precinct to assist in achieving stormwater and sustainability objectives.

Control	Relevance to Broadmeadow Precinct Planning
periodic monitoring and maintenance to ensure the system functions as designed and meets water quality and quantity targets as indicated over the device's life cycle. This includes proposed measures to protect and clean devices during the construction stage of a subdivision	
<u>12.0 Stormwater Drainage</u> C-1. After stormwater is collected and conveyed by the site's onsite controls, it must be discharged from the site via the following: a. pipe connection to street kerb and gutter (preferred) b. connection to CN's underground pipe system (preferred) c. connection to an inter-allotment drainage easement (any proposed easements must have the consent of the burdened properties submitted with the DA) d. direct connection to Hunter Water channel (consent of Hunter Water is submitted with the DA) e. direct connection to waterways and open channels (generally discouraged). C-3. Basement carparks shall be designed with a suitable drainage discharge. Where water cannot drain out via gravity, a pump-out system is to be installed and connected to the site's stormwater network, upstream of any water quality treatment devices. Basement pump-outs are not to be directly connected to the public kerb and gutter. C-4. Discharge to Waterways and Open Channels - Overflow or discharge directly to waterways and open channels is generally only acceptable if it is demonstrated that no other discharge locations are possible. The number of direct point discharges to waterways should be minimised. Where stormwater is proposed to be discharged to natural waterways, designs are to clearly indicate how erosion will be avoided. Plans need to show the length and nature of scour protection extending from the end of civil drainage to a geomorphic stable point, identified by a suitably qualified person.	It is proposed that Council's lot scale drainage controls are maintained across the Precinct to assist in achieving stormwater and sustainability objectives.
<u>13.0 Existing Drainage Systems, Easements and Waterfront Land</u> C-1. Where the development site's drainage system serves other lands, that system is to be protected by an easement in favour of the beneficiary of the drainage system to permit the continued use of the drain. A drainage easement gives the beneficiary the right to maintain the pipes contained in the easement. Where necessary, upstream lots are to be given a legal right to drain through a development site. C-2. Where an existing drainage system across the site is retained, the proposed development is not to obstruct access to the existing system. The development is to be designed to be structurally independent and not degrade the structural integrity of the drainage system. C-5. Development discharging to waterways or is carried out on waterfront land is to meet the Water Management Act 2000	It is proposed that Council's lot scale drainage controls are maintained across the Precinct to assist in achieving objectives. Works in riparian zones and waterway crossings in the Precinct do not cause adverse flood impacts to neighbouring properties for the nominated flood events.

Control	Relevance to Broadmeadow Precinct Planning
requirements and the NSW Government guidelines for riparian corridors on waterfront land. C-7. Where development within riparian zones, including waterway crossings are deemed necessary the following must be complied with: a. designs for proposed waterway crossings and adjustments are to be meet the provisions set out in sub-section 7.0. b. the waterway crossing design must demonstrate that no adverse flood impacts will result for the site and neighbouring properties (in terms of depth, velocity and flood hazard) for the 10% AEP, 1% AEP and 1% AEP in 2050 events. Pending the sensitivity of the site and drainage context, calculated water levels for more frequent storms may be required c. the waterway crossing design must demonstrate how onsite and offsite erosion and blockage risks will be addressed. They must consider and indicate the nature and extent of measures to manage velocity scour and mass failure risks to bed and bank within the site and include riparian native revegetation in any surface stabilisation and landscaping solutions.	

3.2.3 Stormwater and Water Efficiency for Development Technical Manual

The *Stormwater and Water Efficiency for Development Technical Manual* (City of Newcastle, 2019) details Council's design requirements for various water cycle management measures. Although detailed engineering design is not required at structure plan stage, this manual has been considered in the preliminary configuring of regional stormwater quality interventions.

3.3 NSW Flood Inquiry

Following the major flood disasters in 2022, the NSW Government established an independent flood inquiry to investigate the causes, planning, preparedness, response; and recovery from the 2022 catastrophic flood events. As a result of the findings, the inquiry provided 28 recommendations which aim to provide objectives for improved emergency management arrangements, land management and planning, equipment and technology, capacity and capability building and research. The findings of the NSW Flood Inquiry were released in July, 2022[1]. The NSW Government supported six recommendations and supported in Principle 22 recommendations.

The recommendations from the Inquiry are that there is the potential for changes to practices and policies related to:

- Land use, planning and zoning within floodplains;
- The determination of appropriate Flood Planning Levels (FPLs), particularly for locations with a high flood risk;
- Flood warning; and
- Flood evacuation.

[1] https://www.nsw.gov.au/sites/default/files/noindex/2022-08/VOLUME_ONE_Summary.pdf, accessed 17 May 2023.

Key general findings relevant to Broadmeadow are:

- There is clear evidence of rain intensifying at daily and sub-daily scales;
- The intensity of short duration, or hourly, extreme rainfall events has increased;
- As the climate warms, heavy rainfall events are expected to continue to become more intense, with subsequent implications for flash flooding; and
- New buildings must be out of harm's way and made more resilient to the impacts of floods and other extreme weather events.

3.3.1 Specific Findings and Recommendations

The findings and recommendations of the NSW Flood Inquiry are interlinked and their relevance to the Broadmeadow Precinct vary. Key recommendations relevant to the Precinct planning are:

- **Recommendation 18:** Risk-based approach to calculating flood planning level
- **Recommendation 20:** Treat floodplains as assets
- **Recommendation 21:** Simplify the planning system disaster provisions
- **Recommendation 28:** Essential services and floodplain infrastructure.

These are summarised in **Table 3-1.**

Table 3-1. NSW Flood Inquiry - Findings, Recommendations and Relevance to the Broadmeadow Precinct Planning

Finding	Recommendation	Relevance to Broadmeadow Precinct Planning
Finding O. risk-based approach to calculating flood planning level Most landholders using the 1% AEP for calculation of the flood planning level for planning purposes in NSW is not adequate, especially in the light of changing rainfall patterns including the intensification of intra-day rainfall, with the consequent risk of greater flash flooding. To understand risk, especially for major flooding events, knowledge of floods at a catchment wide scale is needed. Councils are generally not adequately resourced or organised to manage either whole of catchment models or high quality, risk-based flood planning level estimations. Responsibility for this matter needs to return to the State Government. Redetermining flood planning levels will be relatively straightforward in some cases with the result remaining close to the 1% % AEP but will need substantial adjustment in others depending on local AEP but will need substantial adjustment in others depending on local rainfall intensities, catchment shape and other risk factors. Intensities, catchment shape and other risk factors.	**18. Recommendation – risk risk-based approach to calculating flood planning level** That, to take account of greater knowledge of climate change, Government account of greater knowledge of climate change, Government reinforce its adoption of a risk risk-based approach to calculating the flood planning level for planning purposes and, through the NSWRA, immediately start a process of revising all flood planning level calculations in the state's high-risk catchments. Flood planning level re re-determinations for all high high-risk catchments should be completed within 3 years. These revised flood planning levels will need to be factored into all development applications (in in-progress and new) in those high high-risk catchments. The risk profile of high-risk catchments should be revisited at appropriate time intervals to check that levels are current. A review should take place if there has been a significant trigger event (i .e. changed rainfall, development) or at least every 5 years. As well as reviewing the flood planning level, this 5-yearly review should include reviewing any floodplain lease conditions and adjusting them as necessary in the light of better knowledge of climate change impacts. In working out a tolerable, risk risk-based flood planning level, consideration should be given to the PMF, 1% AEP, 0.02% AEP, existing development, approved but not yet constructed developments, and existing and approved but not yet constructed evacuation routes.	The Flood Risk Management Manual was gazetted in June 2023. There is a subtle change in language in terms of defined flood events (DFEs) in the Flood Risk Management Manual (2023) when compared to the 2005 Floodplain Development Manual. It includes the principle that flood planning levels be based on a merit assessment, and that floodplain planning needs "to consider the risks associated with the full range of flooding, up to and including the probable maximum flood (PMF)" whilst noting that it is rare that the PMF would be the basis for determining an FPL (with the exception of vulnerable land uses and emergency services, see below). The full range of flood events and the potential impacts of climate change requires consideration when setting the flood planning level for the Precinct. A robust and defendable approach could be achieved using the 'defined flood event' (DFE) concept. The DFE could be defined as: • 1% AEP + future development + climate change. The flood planning level would then apply a freeboard (for example) 0.5m to the DFE. Rezoning for residential or commercial development would be for those areas above the flood planning level. Sensitive land uses within the Precinct such as early education and care facilities, educational establishments and seniors housing would need to be located above the PMF. The full list of hazardous uses is provided in **Section 3.2.1.**

Finding	Recommendation	Relevance to Broadmeadow Precinct Planning
		The Precinct also needs to allow safe evacuation of the floodplain or shelter in place strategies. The approach outlined above does not prohibit urban development below the FPL, rather it encourages development that is compatible with the flood risk applying appropriate flood related controls.
Q – Flooding Floodplain as asset At the moment, there is no coherent or principled approach to proactive, appropriate development of NSW floodplains. Practice to this point has created tensions between the urgent need for more housing and keeping people safe. There is pressure on developers to provide housing, and there is pressure on consent authorities to approve the development, whilst ensuring it is safe and appropriate to do so. Climate change, though not yet fully understood, is increasing this tension. The tension particularly affects those who can't afford to live in suburbs out of the floodplain.	**20. Floodplain as assets** That, to establish the capacity and maximise the economic, social and environmental potential and consequently unlock the value of NSW floodplains, Government adopt the following guiding principles for floodplain management: • treat floodplains as an asset, specialising in uses that are productive and minimise risk to life during major weather events. Such uses would include sporting and recreational activities, garden plots and community gardens, agriculture and forestry, renewable energy production, biodiversity offsets, parks and outdoor education activities. Government should progressively move floodplain ownership to Government leasehold with lessees using the land under appropriately specified conditions. The management of the process of conversion to leasehold would be a Special Project of the NSWRA but over time handing the floodplain asset over to management by another government agency. The NSRWA should prioritise rapid conversion to leasehold in cases where houses and business businesses are in high high-risk areas – this may be accomplished by land swaps or buy backs. In doing so Government achieves early wins for new uses. In other cases, the conversion should occur as a condition of development, of a type that is	Rezoning within the floodplain should consider flood-compatible uses such as sports fields, community gardens, parks and passive recreation. Appropriate zoning in the most flood affected areas may include: • RE1 Public Recreation • C2 Environmental Conservation • C3 Environmental Management. SP2 stormwater drainage or W1 waterway zoning is an option for stormwater drains (closed and open) and tidal waterways respectively.

Finding	Recommendation	Relevance to Broadmeadow Precinct Planning
	consistent with safe evacuation or safety in place in the case of flash flooding that recedes rapidly.	
	• treat development of the floodplain in parallel with development of urban structures (houses, business businesses and industry) that are built near to the edge of the floodplain. Examples of connection could include high-rise housing developments where apartment owners are granted automatic rights and access to community garden and community recreation facilities. Structures within the floodplain and surrounding development should be connected by a layer of sustainable transport.	It may be appropriate to rezone land between the flood planning level and PMF for residential use where flood risk can be managed in the built form e.g.: • R2 Low Density Residential, • R3 Medium Density Residential • R4 High Density Residential Similarly, "E and MU" (formerly B) zoned land may be appropriate on land located between the flood planning level and PMF where risks associated with flooding can be managed in the built form.
	• favour letting watercourses largely flow naturally rather than implementing engineering barriers such as flood levees and mitigation schemes to stop floods.	Returning this section of Styx Creek and its tributaries to a natural state is not feasible considering the constraints of the surrounding urban environment and soil contamination.
R. Finding - simplify the planning system disaster provisions • The new disaster adaptation plans and risk-based approaches to calculating flood planning levels will need to have a clear connection to the development assessment and infrastructure delivery process. It will be critical for new controls to create more resilient buildings to be enforced through development decisions, just as decisions to retreat from high risk areas require support through public space and other infrastructure funding. Achieving these outcomes needs a clear line of sight between policy imperatives for disaster avoidance and adoption, the strategic plans that shape settlement decisions, and the operational	That, to simplify and improve the state planning processes especially when anticipating and recovering from a disaster, Government: • ensure there is a clear line of sight directing councils and planning authorities to include disaster response and resilient settlement outcomes in long term strategic plans (Regional and District Plans as well as Local Strategic Planning Statements). This may require more prominence to be given to Planning for a more resilient NSW: A strategic guide to planning for natural hazards (Department of Planning, Industry and the Environment) as well as a clear link to the risk-based approach to hazard identification and the disaster adaptation plans.	Any proposed changes will need to be considered at exhibition stage.

Finding	Recommendation	Relevance to Broadmeadow Precinct Planning
decisions (like development assessment and spending) that achieve these outcomes. With multiple inputs to the preparation of local planning controls, the line of sight necessary to ensure effective adaptation and resilience to disasters can be obscured. Shifting the responsibility for flood risk management planning to the proposed NSWRA also raises the question of where the development controls for flooding should sit along with the policies that support the inclusion of disaster adaptation plans into strategic planning.	• ensure the NSWRA provides the necessary tools and advice to enable planning authorities to incorporate cumulative impacts of potential natural disasters into strategic plans. These tools should ensure the disaster adaptation plans can be given real effect in strategic plans for settlement and local planning controls.	Any tools will need to be considered when released.
• The division of the planning system into two parts strategic and development control and its operation across two level s of government makes it at times challenging in relation to addressing flooding (and natural disasters more generally).	• ensure that Ministerial Directions on hazard and natural disasters (directions 4.1 and 4.6 inclusive) are updated to reflect the new risk-based approach to flood planning levels and deliver the disaster adaptation plans to the zoning process.	Any updates to the Ministerial Directions will need to be considered.
	• create specific flood planning provisions as a new chapter in the SEPP (Resilience and Hazards). These provisions would draw the existing flood planning clauses (5.21 and 5.22 in the standard instrument) up into the SEPP.	Any possible SEPP provisions will need to be considered when exhibited.
	• put the natural disaster clause (5.9 in the standard instrument) into a new chapter in the SEPP Resilience and Hazards, along with objectives to assist councils to use the clause to build back to more resilient standard.	Any possible SEPP provisions will need to be considered when exhibited.
	• update planning guidance so that wherever possible community facilities, such as might be used for evacuation centres, are located above the probable maximum flood and essential services are located above the flood planning level.	Future guidance will need to be considered when exhibited. At Precinct Planning stage, ensuring schools are located above the PMF is a sensible starting point. Any guidance may inform the future Precinct DCP.
	• ensure that the strategic land use frameworks and related controls permit new developments only in line with the evacuation capacity both individually and cumulatively.	Emergency response strategies have been considered as part of this assessment (refer **Section 4.1.6** and **6.3**).
	• ensure that the strategic land use frameworks enable higher density flood resilient precincts to locate more development at or above the PMF	Higher density precincts should be located above the PMF where possible.

Finding	Recommendation	Relevance to Broadmeadow Precinct Planning
	and use a higher flood planning level to avoid catastrophic costs from extreme flooding, as well as deliver cost effective controls for individual structures.	
W. Finding – essential services and floodplain infrastructure • Essential services disruption in the floods was exacerbated by critical infrastructure being situated in low low-lying areas and consequently being flooded. • Many hospitals, medical centres, nursing homes, aged care facilities and police stations are situated below the flood planning level. Several of these were affected in the recent floods. • Some detrimental impacts of floods come from built structures which are supposed to provide flood mitigation not being maintained and consequently malfunctioning after heavy rain, making floods worse at a local level. local level. Many are the responsibility of several agencies and are maintained by none.	**28. Recommendation – essential services and floodplain infrastructure** That, to minimise disruption to essential services (power, communications, water, sewerage) and to ensure flood infrastructure is fully serviceable before flooding, Government ensure: • essential services infrastructure (communications, water, power and sewerage) is situated as much as possible above the flood planning level. And to minimise disruption to medical services, aged care aged care services and the police, Government ensure hospitals, medical centres, nursing homes, aged care facilities and police stations are situated above the probable maximum flood level. • floodplain infrastructure (drains, levees, flood gates) items are all assigned to an appropriate lead agency which has responsibility for ensuring they are fully maintained and functioning especially when floods are likely.	Essential infrastructure and services should be designed and constructed to be serviceable in the full range of floods up to the PMF. In general, and across the LGA, the large open concrete channels are owned and maintained by Hunter Water Corporation and the pit and pipe network is owned and maintained by Council. This would be continued for these assets within the Precinct.

3.3.2 Local Planning Directions

The Minister for Planning can issue Ministerial Directions to planning authorities about the preparation of planning schemes and amendments to planning schemes.

On 1 March 2022, revised Local Planning Directions were issued relating to, in part, flood resilience and hazard. Of relevance to the Broadmeadow Precinct are the Directions stated under Direction 4.1(1), 4.1 (2), 4.1 (3) and 4.1(4).

Direction 4.1 (1) states that any planning proposal must be consistent with:

(a) the NSW Flood Prone Land Policy,
(b) the principles of the Floodplain Development Manual 2005,
(c) the Considering flooding in land use planning guideline 2021, and
(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.

Direction 4.1(2) states that:

> *A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones.*

Direction 4.1(3) states that:

> *A planning proposal must not contain provisions that apply to the flood planning area which:*

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit development for the purposes of residential accommodation in high hazard areas,
(d) permit a significant increase in the development and/or dwelling density of that land,
(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,
(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or
(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.

Direction 4.1(4) states that:

> *A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:*

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,

(c) permit a significant increase in the dwelling density of that land,

(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,

(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or

(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.

For the proposed Broadmeadow Precinct and first-move rezoning, not all clauses can be satisfied in Ministerial Direction 4.1. However, inconsistency can be acceptable in some circumstances, being:

A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that:

(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or

(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or

(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or

(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.

This assessment constitutes a flood and risk impact assessment prepared in accordance with the Flood Risk Management Manual 2023 and the City of Newcastle LEP 2012 and DCP 2023 requirements, satisfying clause (c) above.

4 Baseline Analysis

4.1 Flooding

Historically, flooding in Newcastle has been exacerbated by the modification of existing creeks into undersized concrete-lined channels which, at the time of construction, were designed for relatively low-capacity flood conveyance. These lined channels are known to overtop their banks relatively frequently and flow into the surrounding streets and properties. Compounding the flooding issue can be the occurrence of elevated sea levels during storm events associated with weather systems, such as East Coast Low events along the coast of NSW.

Styx Creek flows through the suburbs of Islington, Hamilton North, Broadmeadow, New Lambton, Adamstown and Kotara. Under existing conditions Broadmeadow can be considered as one of the most flood-affected areas in the Styx Creek catchment.

Multiple flood investigations have been undertaken in the past, both from an individual development and catchment wide perspective. The *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) is the most contemporary flood analysis of the base case conditions. This study considers a range of design flood events. The Draft Flood Study was publicly exhibited in July-August 2023 and the final Flood Study report has been adopted by Council. Information provided in this report includes design event results from the adopted flood model.

4.1.1 Historic Flooding

4.1.1.1 June 2007

The most significant flooding in recent memory is the storm of June 2007 where high intensity rainfall combined with raised ocean levels to produce widespread flooding across the City of Newcastle LGA. Rainfall was variable across the catchment, with some rainfall gauges (outside of the Styx Creek catchment) receiving over 300 mm in a 24-hour period. It was concluded in both the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) and the preceding study (the *Throsby, Cottage and CBD Flood Study*, BMT WBM, 2008) that this rainfall event was roughly equivalent to a 1% AEP event although at some gauges the depth of rainfall was marginally greater.

Blockage of channels and culverts across the City of Newcastle LGA resulted in significant break out of flows from channels. Blockage was caused not only by typical urban debris (wheelie bins, tree branches, fence palings, etc.) but also by larger items including cars and, in the case of Cottage Creek, shipping containers. The high depth and high velocity flows along roadways were able to mobilise these large items until they were caught in the concrete channels.

The following approximate statistics are sourced from the *Newcastle City-Wide Floodplain Risk Management Study and Plan* (BMT WBM, 2012) highlighting the acute impact to the community the June 2007 event had:

- 10,000 properties inundated in the City of Newcastle,
- 5,000 vehicles written-off in the City of Newcastle,
- 200,000 homes without power in the Hunter, Sydney and Wollongong region,
- 18,500 calls to the SES in the Hunter, Sydney and Wollongong region,
- 2,500 requests for assistance from flooding to the SES in the Hunter, Sydney and Wollongong regions,

- $1.4 billion (not adjusted for inflation) in damages across the Hunter, Central Coast and Sydney areas, and
- Nine lives lost, with one in the City of Newcastle LGA.

Based on historic event calibration flood modelling from the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023), flood depths in the Broadmeadow redevelopment area were estimated to be over 1.0 m for residential areas south of Clyde Street, south of Lambton Road, near the Nineways and across Griffiths Road. Immediately outside the Precinct boundary, similar magnitudes of flooding were experienced in New Lambton, Lambton, Hamilton and Kotara.

4.1.1.2 February 1990

This storm event was also widespread across the region, with rainfall gauges across the City of Newcastle LGA recording from 250 mm to 316 mm over a 48-hour period.

In the Broadmeadow area, peak flood depths were estimated in calibration flood modelling to be of similar extent to the June 2007 event but slightly less in magnitude (less than 1 m in almost all areas outside of the concrete channels).

No lives were lost in this flood event, but damage to property was considered to be extensive.

4.1.1.3 April 1988

In this event, rainfall was significantly variable across the City of Newcastle LGA. In the Styx Creek catchment, rainfall was observed in Kotara to be approximately 100 mm over a 48-hour period.

This event did not produce as significant flooding in Broadmeadow. The residential area south of Clyde Street experienced peak flood depths less than 0.3 m and south of Lambton Road flood depths were modelled to be up to approximately 0.5 m.

4.1.2 Design Flood Behaviour

Flood model results from design flood events for the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) are in **Appendix A**, covering the Broadmeadow redevelopment area and immediate surrounds. The mapping is summarised in **Table 4-1**.

Table 4-1. Flood Maps

Design Flood Event	Peak Flood Depth	Peak Flood Velocity	Peak Flood Hazard
10% AEP	RG-01-100	RG-01-110	RG-01-120
5% AEP	RG-01-101	RG-01-111	RG-01-121
2% AEP	RG-01-102	RG-01-112	RG-01-122
1% AEP	RG-01-103	RG-01-113	RG-01-123
0.5% AEP (1% AEP in 2050)	RG-01-104	RG-01-114	RG-01-124
0.2% AEP (1% AEP in 2100)	RG-01-105	RG-01-115	RG-01-125
PMF	RG-01-106	RG-01-116	RG-01-126

With respect to the Broadmeadow Precinct, flooding begins to affect existing private properties in mapped events as frequent as the 10% AEP. It is possible that areas are flooded in even more frequent events; however, these have not been assessed. The most frequently and significantly flooded areas include:

- South of Lambton Road and west of Styx Creek. This is caused by breakouts from Styx Creek upstream near Saint James Road then re-entering the creek at Lambton Road. Flood waters can be fast moving with high hazard ratings (up to H4 along roadways in the 1% AEP event).
- East of Broadmeadow Road between Styx Creek and Belford Street, at the Showground site. At this location, there is inadequate drainage capacity to convey runoff to Styx Creek and ponding occurs. Flood hazards here are lower (with relatively slow-moving flood waters).
- East of Broadmeadow Road between Griffiths Road and Clyde Street. At this location, there is also inadequate drainage capacity to convey runoff, although the stormwater network here directs runoff to both the Styx Creek to the south and north to Throsby Creek.

In the PMF, flooding is widespread and only a few small areas of any significance in the Broadmeadow Precinct remain flood free. These being:

- Belford Street east of Chatham Street,
- The northwest corner of the Turton Road and Newcastle Road intersection,
- A portion of the property east of Clyde Street and west of Styx Creek (former Gasworks site), and
- The southern extent of the rail line.

4.1.3 Flood Hazard

Flood hazard varies with flood severity (i.e. for the same location, the rarer the flood the more severe the hazard) and location within the floodplain for the same flood event. This also varies with both flood behaviour and in the interactions of the flood with the topography.

The hazard categories mapped are summarised in **Table 4-2** and **Figure 4-1**. These are based on the categories defined in the Australian Disaster Resilience Handbook, Guideline 7-3, Flood Hazard (AIDR, 2017a).

In the PMF, flood hazards extend up to H5 in private property and along roadways. H6 flood hazards are generally confined to the concrete channel of Styx Creek and its tributaries.

Table 4-2. Flood Hazard Category Description

Hazard Category	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

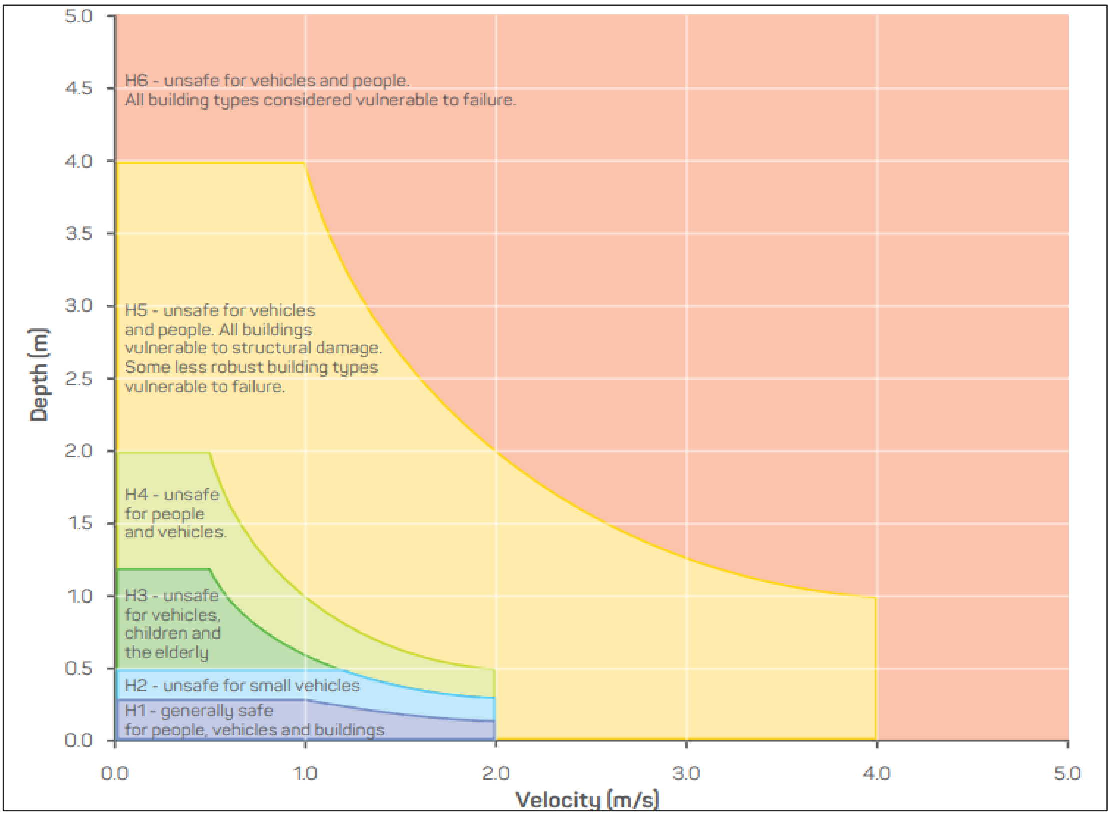

Figure 4-1. Flood Hazard Categories (AIDR, 2017a)

4.1.4 Effects of Climate Change

Climate change will affect two aspects of flooding in this study area:

- Increased rainfall intensity for the same event frequency, and
- Sea level rise affecting the downstream boundary conditions in Newcastle Harbour (Hunter River).

To estimate climate change conditions in 2050, the 0.5% AEP is used as a proxy rainfall event for the 1% AEP event in 2050. In addition, a rise in ocean levels of 0.45 m was applied to bring the ocean boundary condition to 1.85 m AHD.

To estimate climate change conditions in 2100, the 0.2% AEP is used as a proxy rainfall event for the 1% AEP event in 2050. In addition, a rise in ocean levels of 0.95 m was applied to bring the ocean boundary condition to 2.35 m AHD.

The flood behaviour illustrated for the 0.5% AEP and 0.2% AEP and listed in **Table 4-1** represents the effect of climate change for the Broadmeadow Precinct. This results in the 1% AEP event in 2050 having larger peak flood depths up to 0.13 m, primarily in areas closer to Newcastle Harbour (e.g. Hamilton North), but also in upstream areas near Turton Road in New Lambton. For the 1% AEP event in 2100, similar patterns are observed with depths increasing to up to 0.3 m higher than current 1% AEP estimates.

4.1.5 Mitigation Measures from Previous Studies

Flood risk mitigation measures adopted by Council for implementation are reported in the *Newcastle City-Wide Floodplain Risk Management Study and Plan* (BMT WBM, 2012).

The types of flood risk reduction measures are primarily concerned with non-structural options involving:

- Community education initiatives,
- Flood prediction and warning systems,
- Planning Controls,
- Governance initiatives,
- Property works,
- Emergency management, and
- Continuation of existing initiatives.

Whilst no specific recommended actions apply to Broadmeadow; some measures identified to be relevant on a city-wide basis should be incorporated into the redevelopment of Broadmeadow. These being:

- **Education Initiative, Ed.1**: Undertake community education, facilitated through a flood liaison officer.
- **Property Works, Pr.1**: Provide elevated flood-free refuge, in combination with flood evacuation (where required) to minimise pressure loading on buildings (voluntary uptake).
- **Existing Initiatives, Ex.1**: Continue existing development controls for PMF refuge and structural stability needs.
- **Existing Initiatives, Ex.2**: Reinforce controls on building footprints in floodways and flood storages.
- **Planning Controls, Pl.2**: Encourage redevelopment and renovations with more flood resilient materials and design.
- **Flood Prediction and Warning, Wa.3**: Install passive and active road signage to relay warnings, advice of flooded roads, and provide other emergency information.

Implementation costs were provided in a five-year plan costing approximately $4.7 million. No documentation on the status of these recommendations is available.

There were no recommendations for regional-scale flood infrastructure to reduce flood risk for the Newcastle LGA. Community consultation unearthed many ideas from the public, including creek dredging, detention basins, channel enlargement, levees, relocation of suburbs, and diversion of flood waters into mine voids. However, testing of these ideas proved to either be ineffective or currently unfeasible.

4.1.6 Emergency Management

Emergency management generally refers to three separate but related stages:

- Preparedness,
- Response, and
- Recovery.

4.1.6.1 Preparedness

This is primarily revolving around community education and the City of Newcastle's website (https://newcastle.nsw.gov.au/living/environment/flooding) contains multiple resources for identifying current flood risk for residents, workers and visitors. Information is also provided on how individuals can prepare for a significant flood, but this is not specifically targeted to the Newcastle community.

Residents can also register to sign up for a flood alert service based on which catchment in the City of Newcastle LGA they live in.

Flood certificates can be requested by residents to understand current flood planning levels for their properties.

The *City of Newcastle Flood Emergency Sub Plan* (SES, 2013) advises that the following should be undertaken continually to inform and prepare the community for flooding:

- Development of flood intelligence,
- Development of warning systems, and
- Public education (dissemination of brochures, talks at school and to community organisations, etc.).

Warning times in the best conditions would only be a matter of only a few hours if rainfall gauges outside of the LGA and/or radar from the Bureau of Meteorology identify significant rainfall approaching. Effectively, the warning times for catchment flooding can be assumed to be zero.

4.1.6.2 Response

The rapid onset characteristics of flash flooding in the Styx Creek catchment (and the City of Newcastle as a whole) do not provide adequate response time for the community to evacuate effectively. Further to this, roadways tend to be flooded quickly and evacuation routes are cut off. Residents are advised to stay indoors, check on their neighbours, check local media for updates, and take advice from the SES if evacuation orders are given.

The City of Newcastle Flood Emergency Sub Plan (SES, 2013) lists the closest official evacuation centres as:

- Wests Leagues Club, Hobart Road, New Lambton – approximately 1km west of Turton Road along Ker-rai Creek, and
- Adamstown RSL, Brunker Road, Adamstown – approximately 500m south-east of Adamstown Station.

Neither of these centres are located within the Precinct. However, other assembly areas or evacuation centres may be nominated by the SES during an emergency.

In Newcastle, during a flood emergency event, the SES has the primary responsibility to enact rescue operations and assist with recovery.

4.1.6.3 Recovery

Recovery generally includes provision of supplies to flood affected members of the community by the SES as they return to their homes.

The length of time required for each member of the community to get back to 'life as usual' will depend largely on the degree of damage caused to their property, local utility networks and public assets (i.e. roadways). It should be noted that the flooding was so severe in some areas in the June 2007 event that some residents were unable to return to their homes for more than one year.

4.1.7 Flood Function

Maintaining the function of the floodplain is a key objective of best practice in flood risk management in Australia, because it is essential to managing flood behaviour. The flood function of areas of the floodplain will vary with the magnitude in an event. An area which may be dry in small floods may be part of the flood fringe or flood storage in larger events and may become an active flow conveyance area in an extreme event.

Flood function is defined as either:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges.
- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

Preliminary flood function mapping for the Precinct is provided for the PMF and the 1% AEP in 2050 events in **Maps RG-01-150** and **RG-01-151**. The definitions used are the same as those reported in the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023). Refinement of the hydraulic categorisation will be required in subsequent stages of the project to ensure the continuity of floodways.

4.1.8 Flood Emergency Response Classification

Flood Emergency Response Classification (FERC) aims to categorise the floodplain based upon differences in isolation due to the potential for entrapment of an area by floodwaters, potentially in combination with impassable terrain. It also considers the possible ramifications for an isolated area based upon its potential to be completely submerged in the PMF.

Flood Emergency Response Classification mapping is a useful tool for emergency services and evacuation planning for a floodplain. For the purposes of this assessment, it was assumed that existing and future evacuation centres would be located outside of the study area and not be able to be accessed during an extreme flood event, with the exception of McDonald Jones Stadium.

The guideline *Flood Emergency Response Classification of the Floodplain* (AIDR, 2017b) outlines the common approach used for classification nationally. A summary of the classifications is provided in **Table 4-3**.

Table 4-3. Flood Emergency Response Classifications (AIDR, 2017b)

Primary Classification	Description	Secondary Classification	Description	Tertiary Classification	Description
Flooded (F)	The area is flooded in the PMF	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impassable terrain as waters rise during a flood event up to and including the PMF. These areas are likely to lose electricity, gas, water, sewerage, and telecommunications during a flood.	Submerged (FIS)	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
				Elevated (FIE)	Where there is a substantial amount of land in isolated areas elevated above the PMF.
		Exit Route (E)	Areas that are not isolated in the PMF and have an exit route to community evacuation facilities (located on flood-free land).	Overland Escape (FEO)	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.
				Rising Road (FER)	Evacuation routes from the area follow roads that rise out of the floodplain.
Not Flooded (N)	The area is not flooded in the PMF			Indirect Consequence (NIC)	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications, and transport links due to flooding.
				Flood Free (NFA)	Areas that are not flood affected and are not affected by indirect consequences of flooding.

The Flood Emergency Response Classification mapping for the Broadmeadow Precinct (under existing conditions) is shown in **Map RG-01-131**. This classification has a few key assumptions:

- Access to the rail line for overland evacuation is not possible due to existing barriers (i.e. fencing) preventing people from walking into the rail corridor;
- There are small pockets of flood-free land which are not inundated in the PMF scattered across and adjacent to the Broadmeadow redevelopment area, but these locations were not considered significantly large enough to allow people to shelter during a flood event;
- The Flooded, Isolated, Submerged areas were allocated this classification considered there is no land remaining flood free (in accordance with AIDR (2017b) guidance); however these areas could

contain structures where residents could isolate above the PMF elevation, potentially reclassifying these areas to Flooded, Isolated, Elevated (although this classification is not recommended); and

- No rising road access is possible because of major roadways becoming inundated (e.g. Griffiths Road) early during flood events and the likelihood of roadways becoming clogged with traffic an ineffective during a city-wide evacuation.

4.1.9 Flood Planning Constraint Categories

In accordance with the Australian Disaster Resilience Handbook, Guideline 7-5, *Flood Information to Support Land Use Planning* (AIDR, 2017c), flood planning constraints can be divided up to four main categories, but also additional subcategories useful when considering intensifying use or undertaking development on land within these highly constrained categories, such as the Broadmeadow Precinct.

The FPCC approach adopted divides the floodplain using the following definitions inclusive of subcategories, shown in **Table 4-4**.

Table 4-4. Flood Planning Constraint Categories (AIDR, 2017c)

FPCC	Constraint	Implications	Key Considerations	Sub-category
1	Flow conveyance and storage areas in the DFE	Development or changes to topography within flow conveyance areas and flood storages areas affect flood behaviour, which will alter flow depth or velocity in other areas of the floodplain. Changes can negatively affect the existing community and other property.	The majority of developments and uses have adverse impacts on flood behaviour. Consider limiting uses and development to those compatible with maintaining flood function such as SP2 and RE1.	a
	H6 hazard in the DFE	Hazardous conditions considered unsafe for vehicles and people. All building types are considered vulnerable to structural failure.	The majority of developments and uses are vulnerable to failure in this flood hazard category. Consider limiting developments and uses to those that are compatible with flood hazard H6 such as SP2 and RE1.	b
2	Flow conveyance in events larger than the DFE	Flow conveyance areas may develop during an event larger than the DFE. For example, 0.2% AEP if 1% AEP is the DFE. People and buildings in these areas may be affected by flowing and dangerous floodwaters.	Consider compatibility of developments and users with rare flood flows in this area.	a

FPCC	Constraint	Implications	Key Considerations	Sub-category
	Flood hazard H5 in the DFE	Hazardous conditions are considered unsafe for vehicles and people, and all buildings are vulnerable to structural damage.	Many uses and developments will be vulnerable to flood hazard. Consider limiting new uses to those compatible with flood hazard H5 such as SP2 and RE1. Consider treatments such as filling (where this will not affect flood behaviour) to reduce the hazard to a level that allows standard development conditions to be applied. Alternatively, consider a requirement for special development conditions.	b
	Emergency response—isolated and submerged areas	Area becomes isolated by floodwater or impassable terrain, with loss of evacuation route to the community evacuation location. The area will become fully submerged with no flood-free land in an extreme event, with ramifications for those who have not evacuated and are unable to be rescued.	Consequences of isolation and inundation can be severe. Consider the consequences of: • Evacuation difficulty or inundation of the area on the development and its users, which may include limitations on land use, or on land use that has occupants who are more vulnerable to disruption and loss. • The development on emergency management planning for the existing community, including the need for additional treatments • The development on community flood recovery. • Disruption or loss of the development on the users and wider community.	c

FPCC	Constraint	Implications	Key Considerations	Sub-category
	Emergency response—isolated but elevated areas	Area becomes isolated by floodwater or impassable terrain, with loss of an evacuation route to a community evacuation location. The area has some land elevated above the extreme flood level. Those not evacuated may be isolated with limited or no services, and will need rescue or resupply until floods recede and roads are passable	Some developments and their users may be vulnerable to disruption or loss. Consider: • The consequences of disruption or loss of the development on the users and the wider community. • Limiting land use, or land use that has occupants who are more vulnerable to disruption and loss. • Additional emergency management treatment requirements. • Issues associated with the level of support required during a flood, particularly for long-duration flood events.	d
	Flood hazard H6 in floods larger than the DFE	Hazardous conditions may develop in an event rarer than the DFE, which may have implications for the development and its occupants.	Consider the need for additional development conditions to reduce the effect of flooding on the development and its occupants.	e
3	Outside FPCC2—generally below the DFE and the freeboard	Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings that meet building standards unlikely because of flooding.	Standard land-use and development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable users.	-
4	Outside FPCC3, but within the probable maximum flood (or similar extreme event)	Emergency response may rely on key community facilities such as emergency hospitals, emergency management headquarters and evacuation centres operating during an event.	Recovery may rely on key utility services being able to be readily re-established after an event Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users.	-

The City of Newcastle has adopted the defined flood event (DFE) for the Broadmeadow Precinct under the DCP 2023 to be the 0.5% AEP catchment event with appropriate sea level rise, or in other words the 1% AEP event in 2050. The DFE is typically used as a basis for planning purposes to set flood planning areas and flood planning levels combined with appropriate freeboard.

The flood planning constraint categories for the Broadmeadow redevelopment area have been mapped and are presented in **Map RG-01-141**.

4.2 Stormwater Drainage

4.2.1 Stormwater Capacity Analysis

A capacity analysis of existing underground stormwater infrastructure has been undertaken using the TUFLOW model developed as part of the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023). This model includes all pipes of 750mm diameter and greater but does not include smaller pit and pipe networks as these typically do not have a significant impact on overland flood behaviour.

TUFLOW model results were interrogated to determine which drainage lines within the Precinct are running full and those which have additional capacity. This is illustrated in **Figure 4-2** and **Figure 4-3** for the 10% AEP (representing a minor storm) and 1% AEP (representing a major storm) events, respectively.

Results of the analysis revealed that the majority of trunk drainage lines are either operating at capacity or surcharging in both major and minor storm events.

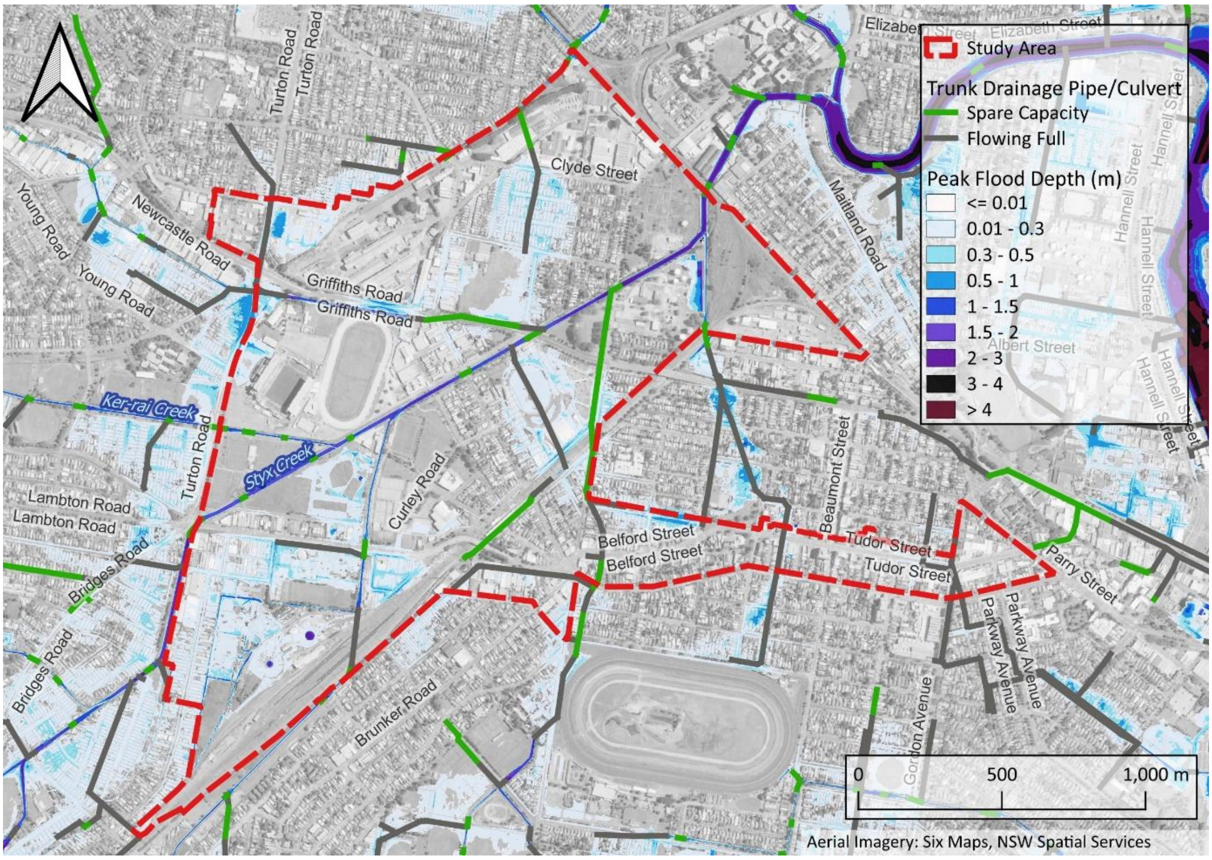

Figure 4-2. Stormwater Capacity Analysis – 10% AEP

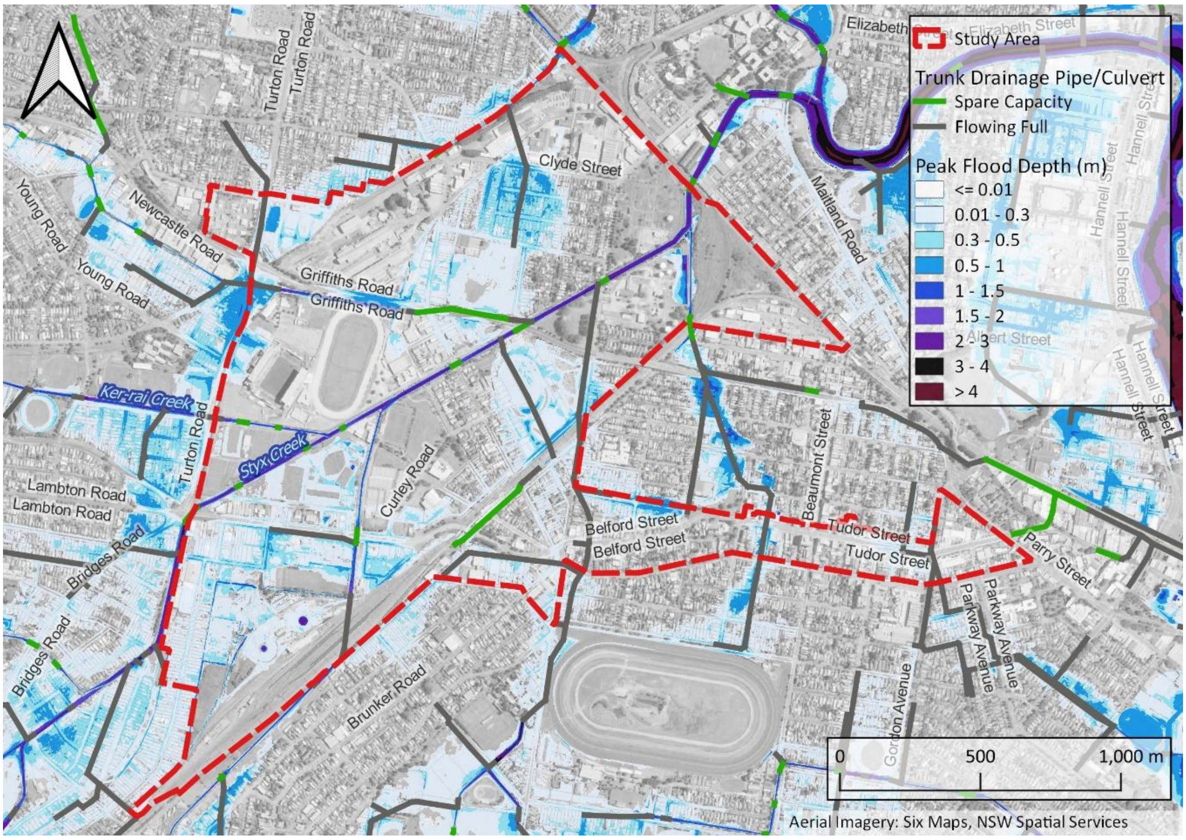

Figure 4-3. Stormwater Capacity Analysis – 1% AEP

4.3 Water Cycle Management

4.3.1 Catchment Water Quality Context

Stormwater generated from the site and upstream catchment discharges largely un-treated to Throsby Creek and Newcastle Harbour. Regional primary treatment measures in the form of gross pollutant traps (GPTs) are present on Ker-rai Creek and the unnamed tributary of Styx Creek that discharges east of the Westpac Rescue Helicopter site. The locations of these GPTs are shown in **Figure 4-4**.

Although no water quality monitoring data was available for Styx Creek or its major tributaries, it is expected that water quality would be poor given the urban nature of the catchment and lack of regional secondary and tertiary treatment measures to remove finer sediment and nutrients from stormwater runoff.

While the Newcastle DCP 2023 requires compliance with load-based water quality targets for new development within the catchment; the majority of urban areas within the catchment were established prior to the creation/enforcement of Council's discharge controls and are likely to discharge untreated stormwater into the waterways.

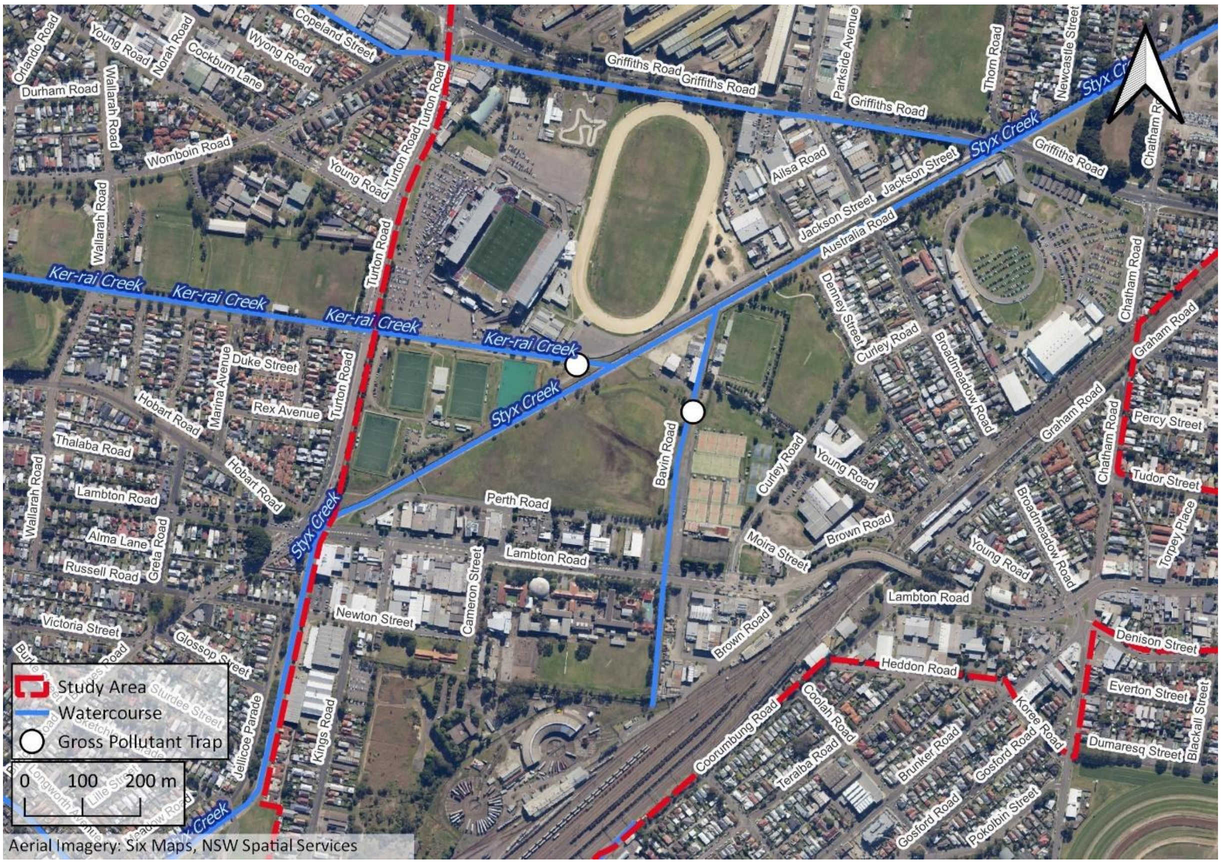

Figure 4-4. Existing GPT Locations

4.3.2 Water Cycle Management Targets

For consistency with long term catchment management objectives set by Council it is recommended the on-site detention and pollutant reduction targets specified in Section C4 of the Newcastle DCP 2023 (and reproduced in **Section 3.2.2**) are adopted for the Precinct.

Compliance with these targets for the Precinct will be achieved via a combination of lot scale (e.g. rainwater tanks) and regional (e.g. constructed wetlands) stormwater management measures to control the quantity and quality of stormwater discharging from the Precinct.

Whilst not a specific requirement of the Newcastle DCP 2023, a Neutral or Beneficial Effect (NorBE) on water quality is often an alternate objective with respect to water quality. However, given the existing highly urbanised nature of the Precinct and limited existing water quality infrastructure within the Precinct, the type and quantum of stormwater treatment measures will be governed by Council's load reduction targets rather than achieving NorBE and will deliver an overall improvement with respect to loads of pollutants discharged to receiving waters.

4.3.3 MUSIC Modelling

A base case MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was established to quantify the existing pollutant loading from the Precinct and broader upstream catchment. Details of the base case MUSIC modelling are provided in the following sections.

4.3.3.1 Catchment Details

MUSIC sub-catchments upstream and within the site were delineated using the hydrologic model sub-catchment delineation from the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) and modified as required to suit the Broadmeadow Precinct boundary and locations of existing stormwater treatment devices. Note that MUSIC modelling does not benefit from the same level of sub-catchment delineation as is typically required for flood modelling. As such, sub-catchments were consolidated around major waterways and equated to a total of 20 in the base case model. **Figure 4-5** shows the sub-catchment delineation adopted in the base case model.

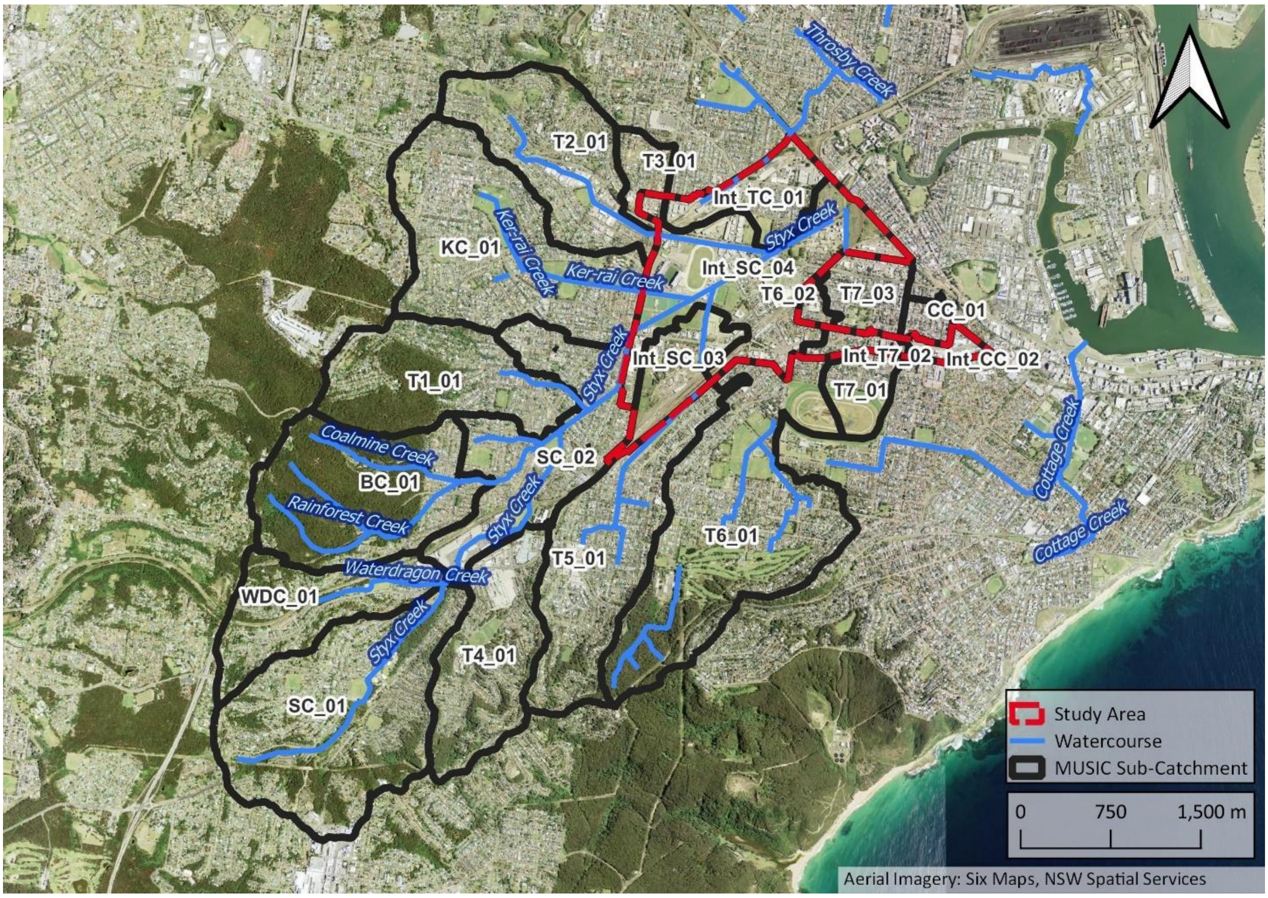

Figure 4-5. MUSIC Sub-Catchments

4.3.3.2 Base Information

Base meteorological data from Council's MUSIC-link (version 6.3.4) was adopted in the model.

4.3.3.3 Source Nodes

Source node types within each sub-catchment were defined based on land use zoning in accordance with Table 5-8 of the *NSW MUSIC Modelling Guidelines* (BMT WBM, 2015). Adopted percentage imperviousness values for each land use zone were based on those from the Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023) and are shown in **Table 4-5**.

Source node pollutant parameters were derived from Council's MUSIC nodes and the NSW MUSIC Modelling Guidelines (BMT WBM, 2015), with stochastic pollutant generation selected for the analysis. Pervious area rainfall/runoff parameters for Catchment Area 3 in Council's MUSIC-link guidelines were adopted across the catchment.

Table 4-5. Land Use Assumptions

Land Use Zone	Source Node Type	Total Impervious Area (%)	Effective Impervious Area (%)
B1, B2, B4, B5, RE2, RU6, SP3	Business	95	76
C1, C2, C3	Forest	0	0
IN2, SP2	Industrial	95	86
RE1, RE2	Residential	25	14
R2, R3	Residential	65	42
R4	Residential	85	55

4.3.3.4 Links

For larger MUSIC models, the application of lag times along drainage lines can be important to account for differences in hydrograph timing across the catchment for the estimation. This is required to produce a realistic estimation of flows and bypasses at treatment nodes.

Link lags were applied in the model to represent the time of concentration of individual sub-catchments and travel time along watercourses.

4.3.3.5 Treatment Nodes

Two treatment nodes have been included in the base case MUSIC model to represent the existing features shown in **Figure 4-4**:

- Open gross pollutant trap (GPT)/trash screen adjacent to the Westpac Rescue Helicopter site
- CDS 3030 (assumed) on Ker-rai Creek.

In the absence of design or work as executed information for these devices, details/parameters have been assumed based on site inspection.

It is understood an online Baffle Box sediment trap is present on Waterdragon Creek. This device has not been included in the base case model as it only treats a small portion of the catchment upstream of the site and is expected to have a negligible impact on results.

Open GPT

The open GPT/trash screen adjacent to the Westpac Rescue Helicopter site has been represented using a generic GPT node in MUSIC.

Pollutant removal efficiencies obtained from field testing have been published for numerous proprietary GPTs. However, there is currently no such data available for offline screen/bay arrangements similar to the proposed device. In the absence of such information, a gross pollutant removal efficiency of 93% has been adopted for the proposed device based on the published removal efficiency of an Ecosol Trash Rack. The Ecosol Trash Rack is a net positioned at conduit outlets with standard 50mm apertures and is expected to remove a comparable percentage of gross pollutants as the subject GPT.

A preliminary high flow bypass of 3.6m^3/s has been assigned based on the measured diversion structure height and Manning's calculations of the channel section upstream of the device.

CDS GPT

The CDS GPT adjacent to Ker-rai Creek has been assumed as a 3030 device based on the size of the contributing catchment (over 200 ha). A corresponding MUSIC treatment node provided by the manufacturer (Rocla, now CivilMart) was used in the model.

4.3.3.6 Results

Table 4-6 below summarises the results of the MUSIC water quality assessment for the existing scenario, including the percentage reduction compared to untreated catchment runoff associated with the regional GPTs.

Table 4-6. MUSIC Model Results

Pollutant	Catchment (un-treated) Loads (kg/yr)	Precinct (un-treated) Loads (kg/yr)	Catchment Outflow Loads (kg/yr)	Percentage Reduction
Total Suspended solids (TSS)	1,970,000	375,000	1,880,000	4.7%
Total Phosphorus (TP)	3,450	640	3,380	2.2%
Total Nitrogen (TN)	26,200	4,780	26,200	0%
Gross Pollutants	340,000	60,900	274,000	19.3%

The results presented in **Table 4-6** suggest that the existing GPTs do not have a significant impact on overall catchment water quality.

5 Emerging Scenario

A preferred land use scenario has been prepared Cox Architects (dated April 2024) based upon:

- Outcomes of the preliminary (3-4 May 2023) and final (11-12 October 2023) Enquiry by Design workshops,
- Baseline analysis and scenario testing reporting by all ten technical works packages, and
- Collaboration between DPHI, Council and consultants leading the various packages.

The layout for the emerging scenario is shown in **Figure 5-1**. For further information on the proposed land use layout, characteristics and yields, reference should be made to the report prepared by Cox Architects in support of this planning proposal.

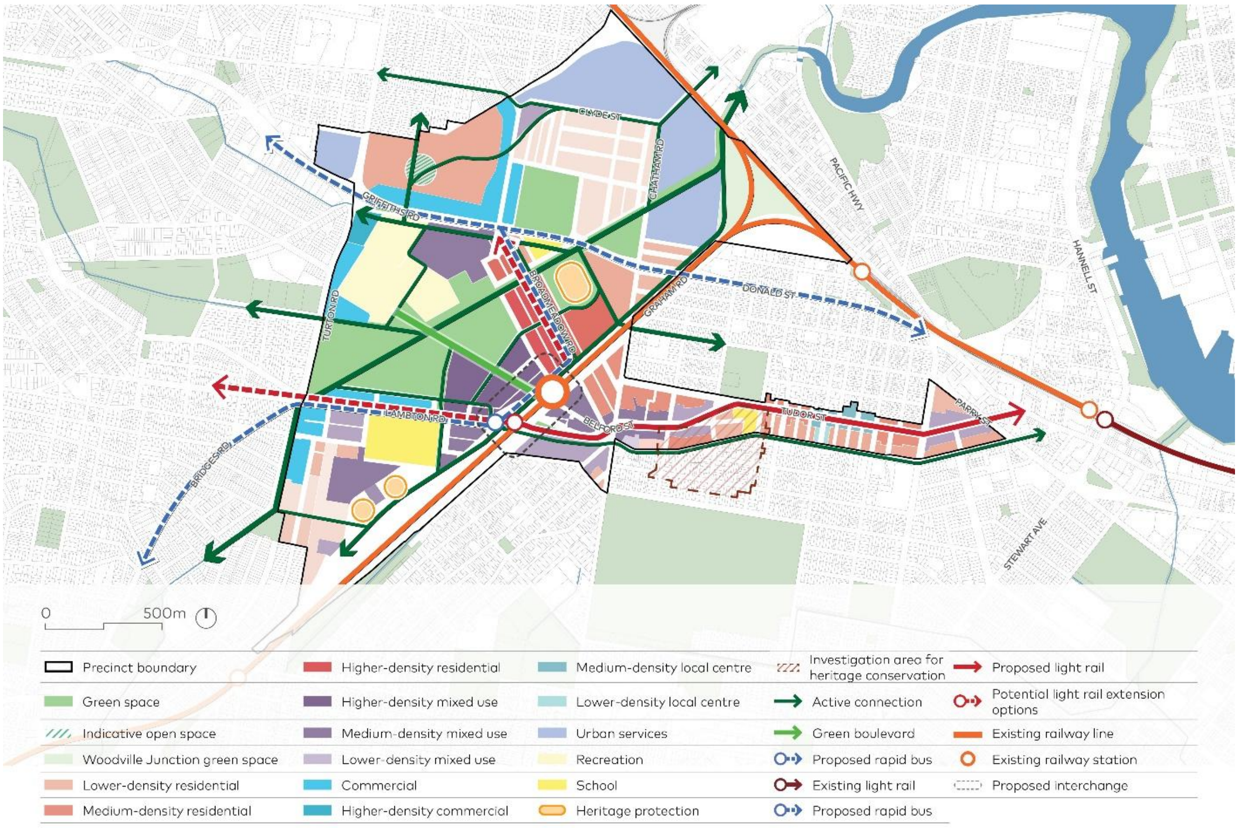

Figure 5-1. Emerging Scenario Structure Plan (Cox, 2024)

6 Flood Impact and Risk Assessment

6.1 Flood Mitigation Strategy

Flood risk is a combination of the likelihood of occurrence of a flood event and the consequences of that event when it occurs. It is the human interaction with a flood that results in a flood risk to the community. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard. Understanding this interaction can inform decisions on which treatments to use in managing flood risk.

As defined in the *Australian Disaster Resilience Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017), there are three types of flood risk:

- **Existing flood risk** – the risk associated with current development in the floodplain. Knowing the likelihood and consequences of various scales of floods can assist with decisions on whether to treat this risk and, if so, how.
- **Future flood risk** – the risk associated with any new development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop and where and how to develop the floodplain to ensure risks to new development and its occupants are acceptable. This information can feed into strategic land-use planning.
- **Residual flood risk** – the risk remaining in both existing and future development areas after management measures, such as works and land-use planning and development controls, are implemented. This is the risk from rarer floods than the management measures were designed for. Residual risk can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk.

The future development of the Precinct represents a significant increase in development in the floodplain, with the PMF extents effectively covering a majority of the study area. As such, a flood mitigation strategy has been developed to manage the flood risk associated with introducing additional population into the floodplain and to prevent additional pressure on emergency services during severe flood events. This strategy is summarised in the following sections.

6.1.1 Development Controls

New development within the Precinct should be subject to the following development controls:

- New buildings should have their ground floor levels designed to be flood resilient. They should be able to structurally withstand the dynamic hydraulic forces of the PMF and areas that are inundated should be able to be easily cleaned of any sediment or flood debris following a flood event.
- The lowest habitable floor levels shall be set at the PMF level, inclusive of allowance for sea level rise.
- All new buildings are to have a suitably sized flood refuge set above the PMF level.
- Basement carparking should be either avoided or accessed via a driveway with the crest set above the PMF level and all ventilation access points also set above the PMF level.
- New development will need to incorporate on-lot stormwater detention to reduce post-development flows to less than or equal to pre-development flows for events ranging from the 50% AEP up to and including the 1% AEP in 2050.

These controls are largely consistent with those in the Newcastle DCP 2023 (refer **Section 3.3.1**).

6.1.2 Education Program

It is proposed that an education initiative in accordance with Section 7.3.1 of the *Newcastle City-Wide Floodplain Risk Management Study and Plan* (BMT WBM, 2012) is established prior to the Precinct development. This should involve the ongoing communication of the proposed emergency management strategy (**Section 6.3**) and flood risk associated with the different portions of the site via a flood liaison officer established by Council.

6.1.3 Flood Modification Measures

Structural interventions are proposed to reduce the flood risk within the Precinct and prevent off-site increases in flooding associated with the loss of flood storage and improved conveyance. These measures include:

- Upgrade of channels and drainage lines that are critical for the conveyance of floodwaters through the Precinct. This includes the widening and partial naturalisation of Styx Creek.
- Diverting breakout flows back to Styx Creek at the upstream extent of the Precinct.
- Raising Lambton Road and Griffiths Road to provide a 1% AEP in 2050 flood immunity. This will improve emergency services access to the Precinct and reduce isolation time in an extreme event such as the PMF.
- Filling of lower lying areas and upgrading downstream drainage lines to reduce the duration of inundation in a PMF event.
- Excavation of select public and privately leased open space areas to provide flood storage/detention to offset increases in flows along Styx Creek. This includes a number of areas upstream and external to the Precinct where flood model testing of the lowering of ground levels was found to be effective at reducing downstream flows.

Mitigation measures are generally focused on areas where there will be a densification associated with proposed changes in land use zoning. No structural interventions are proposed in the eastern-most portion of the Precinct where the land use zoning will remain unchanged.

Proposed structural mitigation measures are highlighted in Figure 6-1 and summarised in **Table 6-1**. It should be noted that the sizing of mitigation measures is to be considered preliminary and is suitable for the purpose of Precinct planning. Confirmation of the proposed mitigation strategy and further engineering concept design will be required in future stages of the project. This may include refinements to the shape and levels of proposed flood storage/detention basins to suit site constraints.

The majority of proposed detention/flood storages will be publicly accessible and thus appropriate flood signage and provision for safe emergency egress will be required to manage flood risk at these locations. For the lowered sporting fields (Smith Park, Kentish Oval, Arthur Edden Oval and Myers Park), the intent is to retain the current sports field functionality during dry weather. The design of these basins will need to include suitable surface and subsurface drainage systems to prevent prolonged field inundation and waterlogging following significant rainfall events. Earthworks batters/edge areas would incorporate seating and amenities would need to be located ideally outside of the basin (except those that could be made flood-compatible).

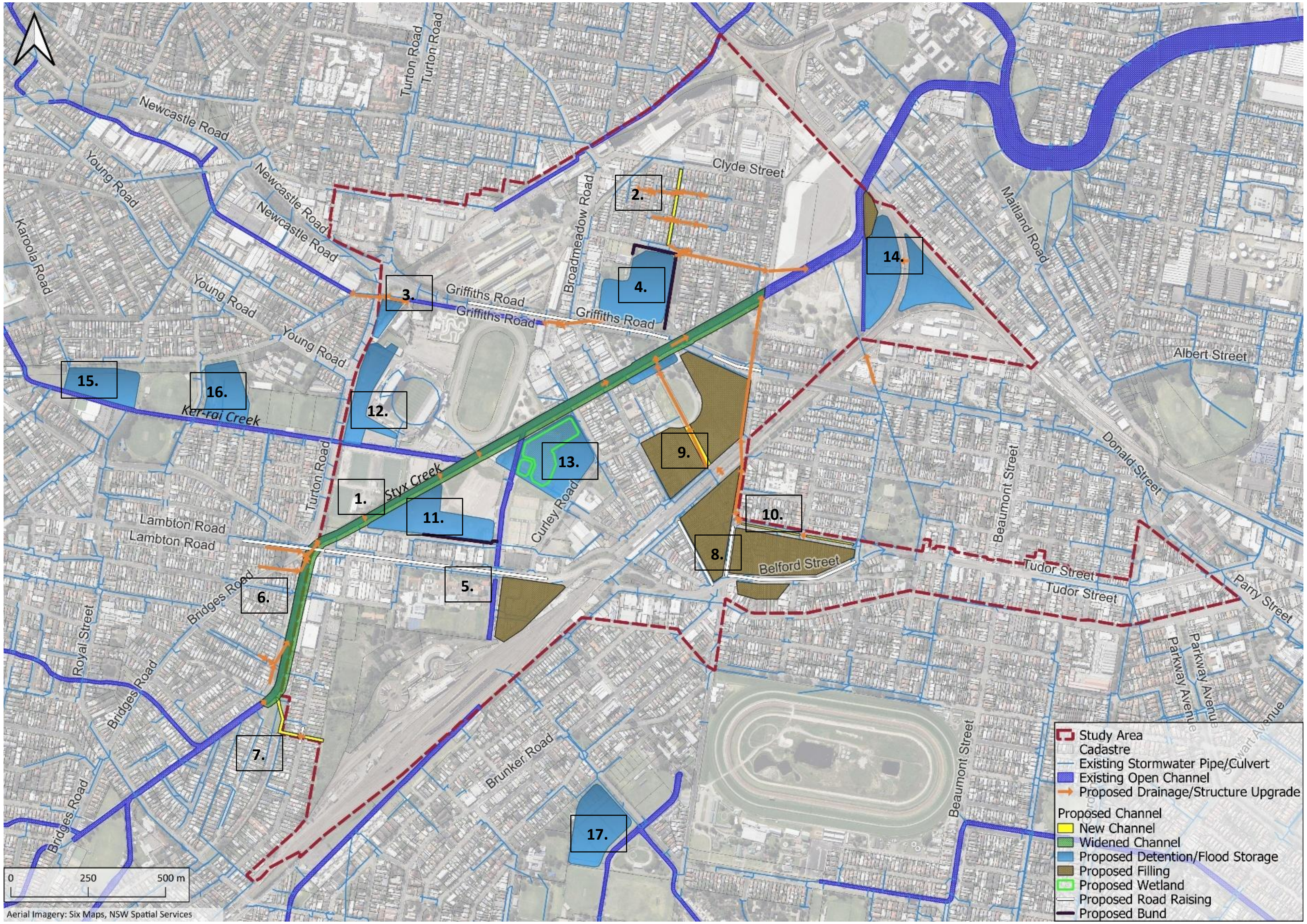

Figure 6-1. Flood Modification Measures

Table 6-1. Flood Modification Measures

Location	Description
1. **Styx Creek Corridor**	Widening and naturalisation of Styx Creek over a 2.2km length between Mackie Avenue and Chatham Road. This comprises the creation of a tiered southern bank with 0.5m high sandstone block retaining walls and 5m wide benches (refer **Figure 6-2**) with planting capable of withstanding high velocity (up to 4m/s in the 1% AEP) flows. The northern bank will remain as per existing due to the presence of an Ampol fuel pipeline (which is not feasible to relocate). Overall, the channel will be widened by approximately 15 – 20m to provide sufficient capacity to convey 1% AEP in 2050 flows. The additional width will assist with creating an active transport and open space corridor. To avoid increased risk of ingress of contaminated groundwater into Styx Creek, it is proposed to line the base of the planted tiers with an impermeable liner. Each of the seven bridge structures between Mackie Avenue and Chatham Road will require upgrade to suit the proposed channel section, inclusive of the Mackie Avenue bridge. The Lambton Road bridge requires further modification to achieve a cross sectional area of approximately 75m^2 beneath the bridge soffit.
2. **Hamilton North**	A number of drainage upgrades are proposed in the residential Hamilton North area to provide a 1% AEP in 2050 flood immunity and reduce the duration of inundation in a PMF event. This includes: • A 10m wide open channel draining in a southerly direction between Clyde Street and Boreas Road, with twin 2.7m wide x 0.9m high box culverts at each road crossing. The cross section of this channel comprises a 3m wide concrete base with planted benches and sandstone retaining walls. Similar to the Styx Creek works, it is proposed that the planted benches are underlain by an impermeable liner to prevent the ingress of potentially contaminated groundwater. The channel is aligned through existing private properties (6) which would need to be acquired. • A twin 3.6m wide x 1.8m high box culvert draining west along Boreas Road and discharging into Styx Creek. This culvert bisects the southern corner of the gasworks site. • Upgrade of local drainage lines connecting to the trunk drainage channel and culverts. These upgrades will also include the provision of additional inlet pits where required to sufficiently manage ponding in the road reserves.
3. **Griffiths Road**	Proposed Griffiths Road upgrades include: • Duplication of the 2.7m wide x 1.5m high box culvert extending between Womboin Road and the open channel to the south-east of the Griffiths Road/Turton Road intersection. This upgrade will provide a 1% AEP in 2050 flood immunity along the adjacent section of Griffiths Road. • Road raising by up to 1m to reduce the amount of time the road would be considered non-trafficable by emergency services during a PMF event (refer **Section 6.3**). This is required over a total length of approximately 800m. • Provision of a 3.6m wide x 1.8m high box culvert alongside the existing 3m wide x 1.5m high culvert that runs under Griffiths Road to the east of the Newcastle Harness Racing Club to provide a 1%

Location	Description
	AEP in 2050 flood immunity. This culvert will discharge into the proposed Smith Park storage (refer location #4 below).
4. Smith Park	An approximately 4.0 ha detention/flood storage area within Smith Park. Detention will be provided by lowering ground levels to RL 3.5m AHD, providing a diverted 3.6m wide x 1.8m high culvert inflow from Griffiths Road and a 1.35m diameter pipe outlet in the north-eastern corner that connects to the proposed trunk drainage line along Boreas Road. A low flow channel/swale will also be required along the southern and eastern boundary to convey low flows between the basin inlet and outlet. An earthen bund to RL 5.5m AHD is proposed around the northern and eastern boundaries to increase the storage capacity and reduce the quantum of spoil for disposal (from the lowering works).
5. Lambton Road	Similar to Griffiths Road, it is proposed to raise Lambton Road to provide a 1% AEP in 2050 flood immunity and reduce the duration of inundation in a PMF event. This will involve raising approximately 500m of Lambton Road by up to 1m. Filling by up to 1m is also proposed over the mixed-use area between the Hunter School of Performing Arts and the railway line to reduce PMF duration of inundation and flood hazard in this area.
6. Sturdee Street to Lambton Road	The raising of Lambton Road prevents floodwaters overtopping the road immediately west of the Precinct, causing afflux over upstream properties if left unmitigated. As such it is proposed to upgrade select stormwater drainage lines between Sturdee Street and Lambton Road to offset these impacts. This includes: • A series of twin 1.2m diameter pipes along the southern kerb and gutter of Lambton Road between Kurraka Reserve and the outlet to Styx Creek upstream of the Lambton Road bridge crossing. • A series of twin 0.6m high x 1.2m wide box culverts between the Russell Lane low point and Styx Creek. • Drainage lines of up to 1.2m diameter pipes along Sturdee Street and Jellicoe Parade. • Additional inlet pits along each of the upgraded drainage lines.
7. Mackie Avenue Reserve	A 10m wide grassed channel is proposed to capture breakout flows arriving at the southern Precinct boundary and direct these floodwaters back to Styx Creek. Road and lot raising by approximately 0.2m is proposed immediately north of this location to divert floodwaters flowing north along Kings Road into the channel.
8. Belford Street	Filling of proposed residential and mixed-use areas by up to 1.2m between Belford Street and the railway line, including adjacent roadways. This is proposed to reduce PMF duration of inundation and flood hazard in this area. Filling of land can be completed in stages with temporary drainage works implemented to prevent adverse flooding impacts on adjacent properties. A set of 10 x 3.6m wide x 1.2m high box culverts under the railway line is also proposed to address the duration of inundation issues in this area by providing an above ground overflow route for water ponding against the railway embankment.
9. Newcastle Showground	A number of mitigation measures are proposed around the Newcastle Showground site to address flooding issues in this area. These include:

Location	Description
	• Filling of the proposed medium and high density residential areas by up to 1m to reduce PMF duration of inundation and hazard. Filling of land can be completed in stages with temporary drainage works implemented to prevent adverse flooding impacts on adjacent properties. • Duplication of the 1.35m wide x 1.2m high box culvert line traversing the Showground site between the railway line and Styx Creek. • Provision of a 20m wide overland flow path within the existing stormwater easement between the railway line and inner oval of the Showground. • Lowering of ground levels to RL 4.5m AHD north of the Showground perimeter road to increase flood storage and overland flow connectivity to Styx Creek.
10. Tudor Street	Under existing conditions, the western-most section of Tudor Street forms a trapped low point where significant ponding occurs due to the insufficient capacity of local and downstream drainage infrastructure. To address this, it is proposed to provide a 5m wide grassed open channel within the Tudor Street median strip that drains in a westerly direction between Samdon Street and Chatham Street. Twin 1.8m wide x 0.9m high box culverts are proposed across the intersection with Blackall Street and a 3.6m wide x 1.8m high box culvert is proposed at the western end of the channel to connect to the downstream Hunter Water trunk drainage line. Downstream of Tudor Street, it is proposed to duplicate the 4.1m wide x 2.5m high culvert line that drains in a northerly direction and outlets into Styx Creek upstream of the Chatham Road bridge.
11. Knights Centre of Excellence	An approximately 3.4 ha detention/flood storage area is proposed in the southern portion of the Knights Centre of Excellence site. This storage will be provided by lowering ground levels to RL 6.0m AHD and providing a constriction in Styx Creek immediately downstream of this location. An earthen bund with a height to RL 7.8m AHD is proposed around the southern end of the basin to prevent floodwaters spilling towards Lambton Road and reduce the quantum of spoil for disposal.
12. McDonald Jones Stadium	An approximately 3.0 ha detention/flood storage area is proposed to the west of McDonald Jones Stadium split between a 0.6 ha area in the north and a 2.4 ha area in the south. This storage will be provided by lowering ground levels to RL 6.0m AHD and providing a constriction in Ker-rai Creek immediately downstream of this location.
13. Magic Park	An approximately 4.6 ha detention/flood storage area is proposed over Magic Park site and adjacent parcel of land currently occupied by the Westpac Rescue Helicopter facility. This storage will be provided by lowering ground levels to RL 5.0m AHD and providing a constriction in the unnamed tributary of Styx Creek immediately downstream of this location. This area serves to reduce flood risk with the additional flood storage volume and provide improved water quality with an incorporated wetland.
14. Railway Junction	Approximately 5.6 ha of detention/flood storage area, split between two basins, is proposed in the biodiversity area within the railway corridor at the northern end of the site. This storage will be provided by lowering ground levels to RL 3.0m AHD either side of the railway and providing a constriction in Styx Creek immediately downstream of this location. The two storages will

Location	Description
	be connected by a set of 5 x 3.6m wide x 1.2m high box culverts under the railway line. A small fill area to a minimum RL 4.5m AHD is proposed to the north of the western basin to reduce the quantum of spoil for disposal. To offset the increases in flood levels associated with the Styx Creek constriction, it is proposed to provide a 1.2m wide x 0.6m high culvert running parallel to the existing 1.2m wide x 1.2m high culvert between Donald Street and the railway.
15. Kentish Oval	An approximately 2.3 ha flood storage area is proposed over Kentish Oval, to the west of the Precinct. This increased flood storage will be provided by lowering ground levels to RL 8.0m AHD.
16. Arthur Edden Oval	An approximately 2.4 ha flood storage area is proposed over Arthur Edden Oval, to the west of the Precinct. This increased flood storage will be provided by lowering ground levels to RL 7.5m AHD.
17. Myers Park	An approximately 3.3 ha flood storage area is proposed over Myers Park, to the south of the Precinct. This increased flood storage will be provided by lowering ground levels to RL 5.0m AHD.

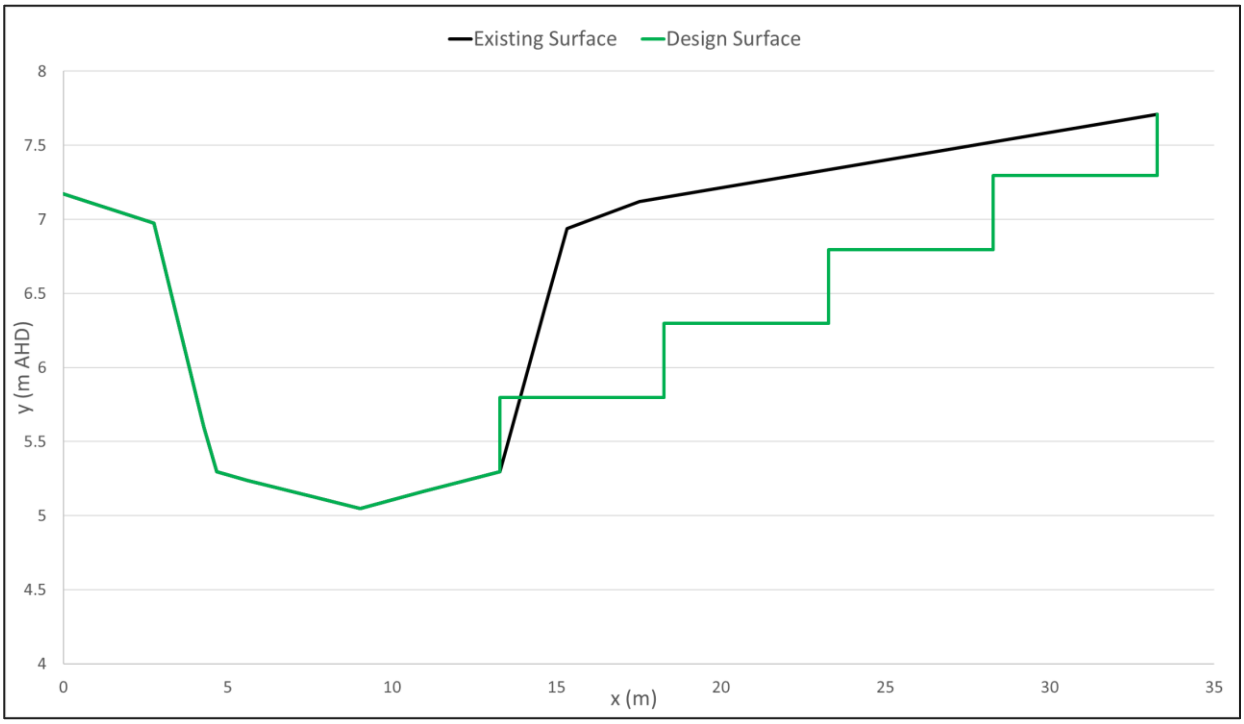

Figure 6-2. Styx Creek Widening - Typical Section – Existing and Proposed Design

6.1.3.1 Alternate Detention Strategy

An alternate detention strategy was explored involving the provision of a 11.7 ha, 2m deep detention basin within the inner portion of the Newcastle Racecourse. For this option, flows would be diverted into the basin from the 3.75m wide x 2.5m high Hunter Water trunk drainage culvert to the west of the Racecourse.

Preliminary flood modelling revealed this option provides sufficient flow attenuation to eliminate the need for flood storages external to the Precinct, and potentially reduce the required detention/flood storage volume within the Precinct. However, this option was not progressed due to the reliance of detention within privately-owned land external to the Precinct.

6.2 Post Development Scenario Flood Modelling

6.2.1 Model Updates

The base case TUFLOW hydraulic model from the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) was updated to include relevant features of the Emerging Scenario and flood mitigation strategy. Model updates to reflect the post-development scenario are summarised in **Table 6-2.**

It is assumed that lot scale on-site detention will be provided to reduce post-development flows to pre-development levels and, therefore, updates to the WBNM hydrology model were not considered necessary.

Table 6-2. Flood Model Updates

Parameter	Data Source/Assumptions
Digital Elevation Model (DEM)	Modifications to the model DEM were made to represent: • Proposed flood storages/detention areas, • Proposed embankments/bunds, • Road raising, • Proposed filling, and • Proposed channels/overland flow paths. These were incorporated into the model using TUFLOW 'Z shapes'.
Roughness	Surface roughness mapping was updated across the Precinct to reflect the proposed rezoning and mitigation measures, with adopted values remaining consistent with corresponding land uses/surface types from the Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023) model. Adopted Manning's 'n' values specific to the developed Precinct include: • Urban 0.300 • Public open space 0.030 • Detention / flood storage 0.030 • Naturalised channel section 0.060 • Grassed channel / flow path 0.030
1D Channels	The 1D channel network and corresponding cross sections were updated to reflect the proposed Styx Creek widening/naturalisation and new channel through Hamilton North. Cross sections were also modified to represent the proposed creek constrictions downstream of storage areas.
1D Bridges	Bridge cross sections were updated where necessary to suit the proposed cross-sectional profile associated with the Styx Creek widening/naturalisation.
1D Stormwater Network / Culverts	The 1D pit and pipe/culvert network was updated to suit the proposed upgrade arrangement. Blockage assumptions for upgraded culverts and drainage lines remain as per the existing scenario model; whereas nil blockage has been applied to detention basin outlets as this is more conservative in terms of downstream flood impacts.

Parameter	Data Source/Assumptions
BMT (2023) Broadmeadow Locomotive Precinct Model Inputs	Relevant features of the TUFLOW model developed by BMT for the proposed Broadmeadow Locomotive Precinct rezoning (refer **Section 2.5**) were provided for incorporation into the broader Precinct model. This included: • Post-development DEM, • Roughness polygons, • Bridge layered flow constrictions, and • 1D stormwater network. Model data were generally left unaltered from the BMT (2023) model. Smaller features of the proposed stormwater network (less than 750mm in diameter) were removed to remain consistent with the assumptions of the Throsby, Styx and Cottage Creek Flood Study (Rhelm, 2023).

6.2.2 Hydraulic Model Results

Incorporating the flood modification strategies listed in **Table 6-2** and the proposed development itself, to form the 'post-development' TUFLOW model, the critical 10%, 5%, 2%, 1%, 1% in 2050 and 1% in 2100 AEP events and the PMF event were considered. The model was run for the same storm durations and temporal patterns as the base case model from the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023), with the results 'enveloped' to extract maximum values from the different storm durations.

Post-development scenario flood maps have been attached in **Appendix B** of this report and are summarised in **Table 6-3**.

Table 6-3. Post-Development Flood Maps

Design Flood Event	Peak Flood Depth	Peak Flood Velocity	Peak Flood Hazard	Flood Function	Flood Level Impact
10% AEP	RG-02-100	RG-02-110	RG-02-120	-	RG-02-129
5% AEP	RG-02-101	RG-02-111	RG-02-121	-	RG-02-130
2% AEP	RG-02-102	RG-02-112	RG-02-122	-	RG-02-131
1% AEP	RG-02-103	RG-02-113	RG-02-123	-	RG-02-132
0.5% AEP (1% AEP in 2050)	RG-02-104	RG-02-114	RG-02-124	RG-02-127	RG-02-133
0.2% AEP (1% AEP in 2100)	RG-02-105	RG-02-115	RG-02-125	-	RG-02-134
PMF	RG-02-106	RG-02-116	RG-02-126	RG-02-128	RG-02-135

6.2.2.1 Post-Development Flood Behaviour

Results of the post-development flood model suggest that the proposed flood modification actions provide a 1% AEP in 2050 flood immunity to lots where rezoning to more densely populated land uses is proposed. An exception to this is the Council depot site at the corner of Griffiths and Turton Road where 1% AEP in 2050 flooding depths reach up to 0.8m over an area nominated for a land use change from general industrial to medium density residential in the emerging scenario. It is recommended that the existing land use is retained over this area to avoid an increase in flood risk and loss of flood storage area. Alternatively, incorporating further structural flood mitigation works into the site design may eliminate the flood risk impacts.

Another exception is the Broadmeadow Locomotive Precinct where shallow flooding (less than 0.1m) is observed over a few proposed high density residential lots in the 1% AEP in 2050. Results of the higher resolution modelling from the site-specific assessment (refer **Section 2.5**) show these lots as flood free in the 1% AEP plus climate change event, with the minor flooding present in the Precinct-scale model attributed primarily to the coarser model resolution and inflow application.

In the 1% AEP in 2050 event, shallow overland flooding (up to 0.1m in depth) is present over an area of land use change from local centre to mixed use between Lambton Road and the railway. This could be managed by incorporating non-habitable ground floor levels designed to be flood compatible or additional localised drainage upgrades/diversions to manage overland flow.

Overland flooding remains present over residential areas in the eastern portion of the Precinct where land uses will remain as existing. Site-specific assessments will be required for any proposed development in these areas to demonstrate compliance with the Newcastle LEP 2012, Newcastle DCP 2023 and the *NSW Flood Risk Management Manual* (DPE, 2023).

Despite the effectiveness of the proposed mitigation strategy in managing flooding in events up to and including the 1% AEP in 2050, significant inundation remains across the Precinct in the PMF event. Proposed emergency management measures to limit the risk to life in this event are discussed in **Section 6.3**.

6.2.2.2 Flood Impacts

Flood impact mapping generally shows either nil impact or a reduction in peak flood levels on private property external to the Precinct for events ranging from the 10% AEP up to and including the 1% AEP in 2050. Substantial reductions in external flood levels within private residential properties (up to 0.5m in the 1% AEP in 2050 event) are observed along the western boundary which can primarily be attributed to the Lambton Road raising and Griffiths Road culvert upgrades. The overall results represent a net positive improvement for flood risk in the local region with reductions of flood depths, hazard, duration and emergency access.

Increases in the 2% AEP flood event levels of approximately 0.01m are observed immediately downstream of the Precinct between the northern boundary and Chinchen Street, extending onto private property west of Hubard Street. These impacts could be eliminated in subsequent stages of design with minor refinement to the outlet controls of proposed flood/detention storages.

Impact mapping also shows minor increases (generally less than 50mm) for off-site flood levels in a number of locations surrounded by reductions in flood levels and extents. This is a product of the local inflow application methodology from the *Throsby, Styx and Cottage Creek Flood Study* (Rhelm, 2023) whereby flows are distributed evenly across wet cells within polygons equivalent to their respective sub-catchments. As a result, if the flood extents are reduced in one area due to the flood modification measures, this will distribute more flow from the local sub-catchment to other wet cells within the sub-catchment boundary. Notable examples of these 'artificial' impacts are the southern end of Mayfield and south-west of the Styx Creek/Throsby Creek confluence, both of which are upstream of areas where peak flood levels are reduced in the post-development scenario and would not have any physical reason for an increase in flood levels. In some locations, these effects are more pronounced in more frequent events (such as the 10% AEP) due to the reduced buffering from overland flows originating further upstream.

In the PMF event, off-site increases in flood levels are generally less than 0.2m and would not result in any significant increase in the risk to life. A number of these impacts can likely be attributed to the inflow application effects described above. Off-site reductions in PMF levels due to the improved stormwater and creek conveyance are more substantial than the minor and/or localised increases in levels.

The works associated with the Precinct development will provide a net benefit on flood levels in the PMF for the region.

Within the Precinct, flooding is substantially reduced where required to support residential development and increased on more flood-compatible land uses (such as recreational uses). Flooding is also substantially improved in the Hamilton North area where the land uses are proposed to remain as per existing (low density residential). The proposed drainage upgrades in this area are sufficient to eliminate flooding in events in private properties up to and including the 1% AEP in 2050.

6.3 Emergency Management

As discussed in **Section 4.1**, the flash flooding nature of the Styx Creek catchment does not provide sufficient response time for the safe evacuation of the floodplain in a severe rainfall event. A shelter in place strategy is considered the safest option for the Precinct considering the risk to life is primarily posed by flooding of the roads. However, for a shelter in place strategy to be considered appropriate, residents seeking refuge must not be isolated from emergency services assistance for prolonged periods of time. The *Draft Shelter-in-place Guideline* (DPE, 2023) nominates a maximum 6-hour duration of inundation threshold for shelter in place strategies.

Despite the rapid rate of floodwater rise within the Precinct, there are several locations in the Precinct where floodwaters currently take a relatively long time to drain. This is largely caused by inadequate drainage infrastructure and lack of overland flow paths connecting to the creeks.

A duration of inundation assessment was undertaken to determine the PMF inundation time across the Precinct under existing conditions. This assessment was repeated for the post-development scenario to demonstrate that the inundation duration is reduced to less than the 6-hour flash flooding threshold for parts of the Precinct where up-zoning/densification is proposed. These assessments involved the following:

- Running the PMF event for the critical duration relevant to the Precinct (3 hours) and the maximum duration from the Generalised Short Duration Method (6 hours).
- Producing a duration of inundation envelope from the above durations. Given that floodwaters can generally be safely traversed if sufficiently shallow and slow moving, the duration of inundation was considered to be the length of time flood hazard exceeds a H1 classification (refer **Section 4.1.3**).

The PMF duration of inundation across the Precinct for the existing and post-development scenarios is shown in **Figure 6-3** and **Figure 6-4** respectively.

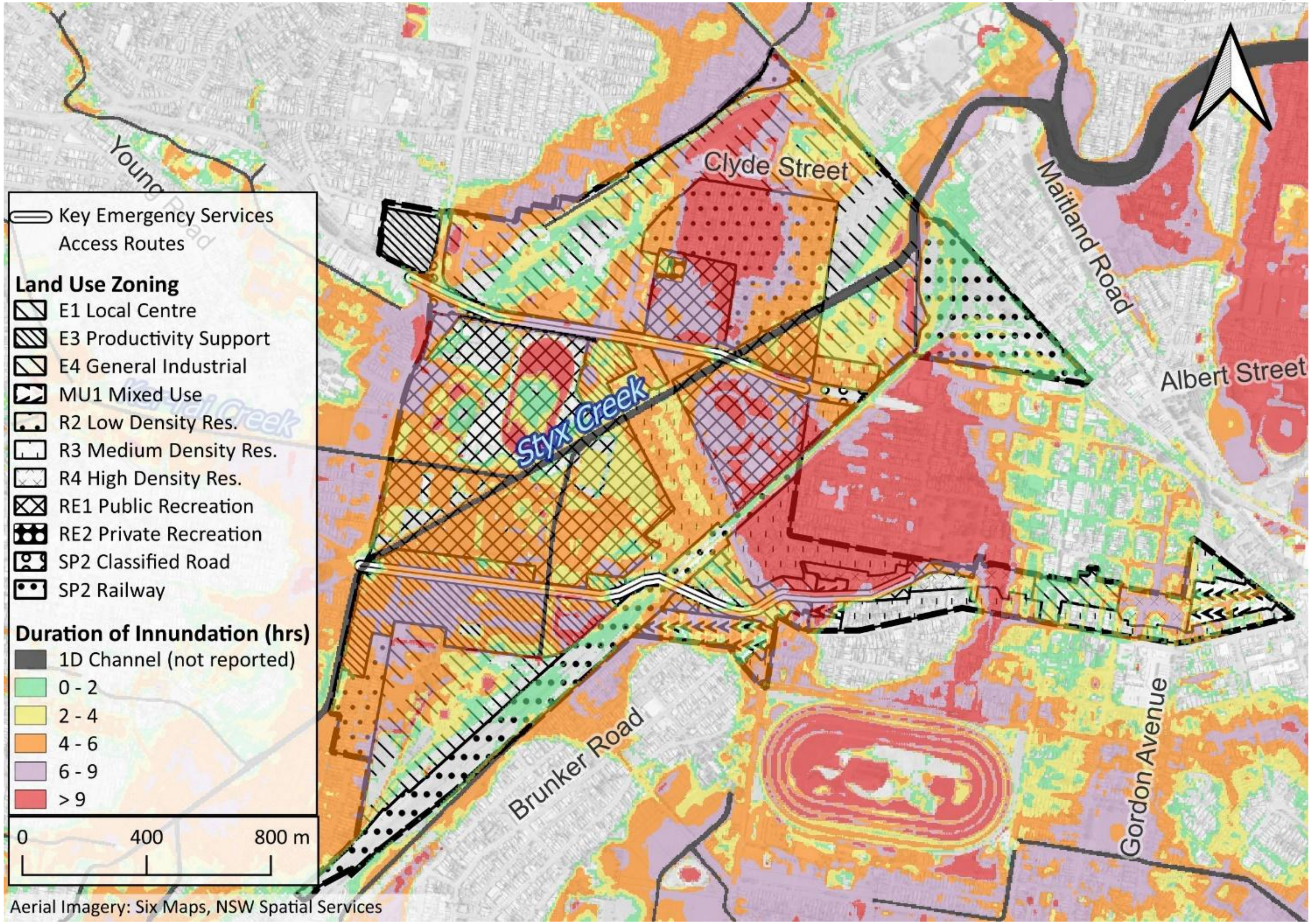

Figure 6-3. PMF Duration of Inundation for Conditions > H1 Hazard – Existing Scenario

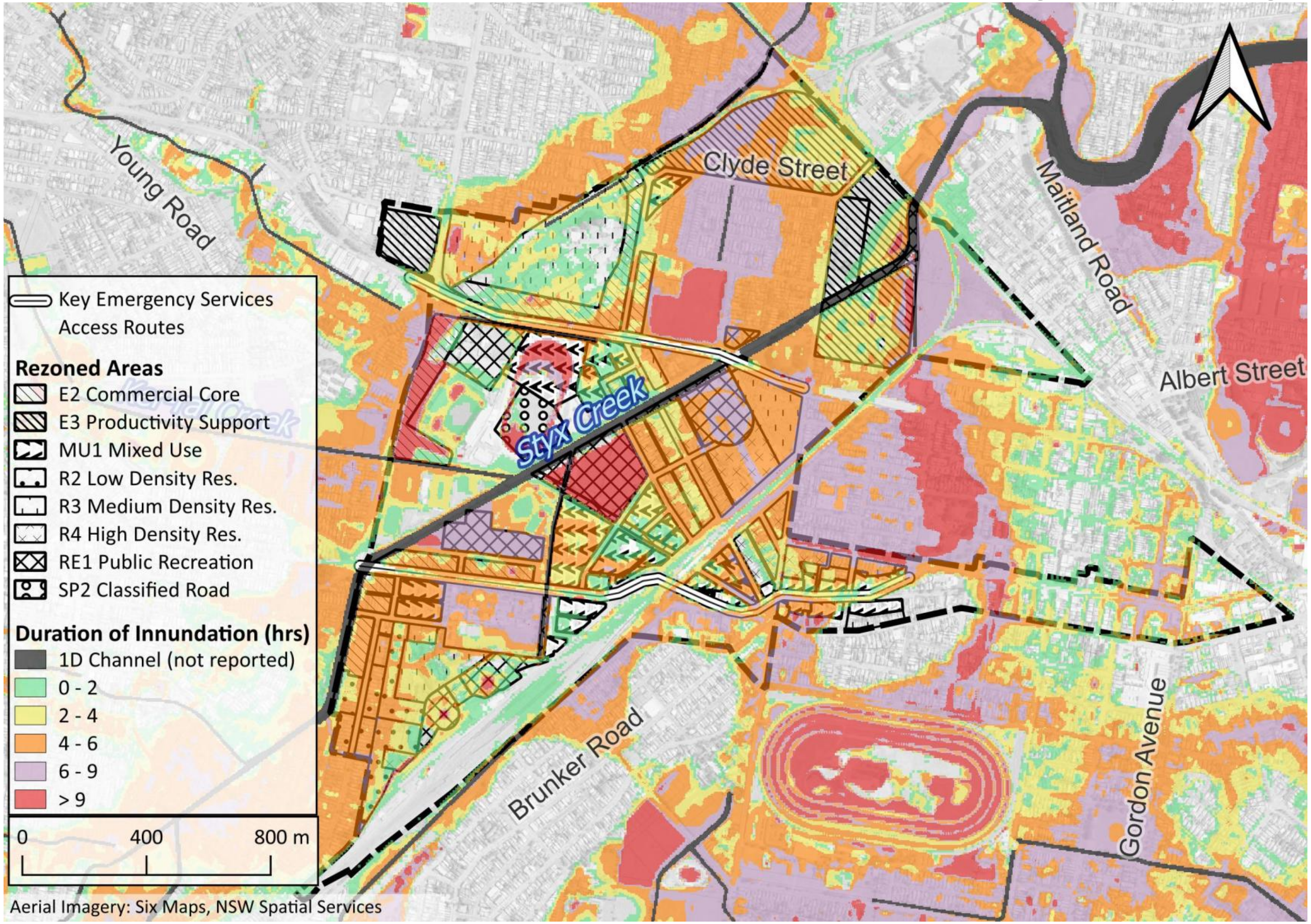

Figure 6-4. PMF Duration of Inundation for Conditions > H1 Hazard – Post-Development Scenario

As shown in **Figure 6-4**, the duration of inundation in the post-development scenario is less than 6 hours across all areas where additional population will be introduced to the floodplain as a result of the proposed rezoning. The duration of inundation is also reduced to less than 6 hours along the critical emergency services access routes of Griffiths Road and Lambton Road.

The post-development duration of inundation within the low-density residential portion of Hamilton North slightly exceeds the 6-hour threshold in the lower lying areas, reaching a maximum of approximately 7.5 hours. This, however, is a significant improvement compared to existing conditions where properties are inundated by floodwaters of hazard category H2 and above for over 15 hours. Given that no up-zoning/densification is proposed in this area, the reduction in duration of inundation corresponds with a reduction in overall flood risk.

The post-development duration of inundation also remains higher than the 6-hour threshold in the higher density residential areas in the easternmost portion of the Precinct where land zoning will remain as per existing. Any future development proposals in this area should include site-specific flood emergency management arrangements to demonstrate the proposed development is compatible with the flood risk and will not place additional pressure on emergency services.

6.4 Flood Planning Area

The flood planning area relevant to the fully developed Precinct has been calculated as follows based on the results from the post-development flood model:

- Adding 0.5m freeboard to the 0.5% AEP (1% AEP in 2050) peak water level grid,
- Extending the raised water level grid to the point of intersection with the post-development surface DEM,
- Trimming the above grid to limit the flood planning area to the extent of the PMF in those locations where it exceeds the PMF extent.

The flood planning area and flood prone land (PMF) extents are shown in **Figure 6-5**.

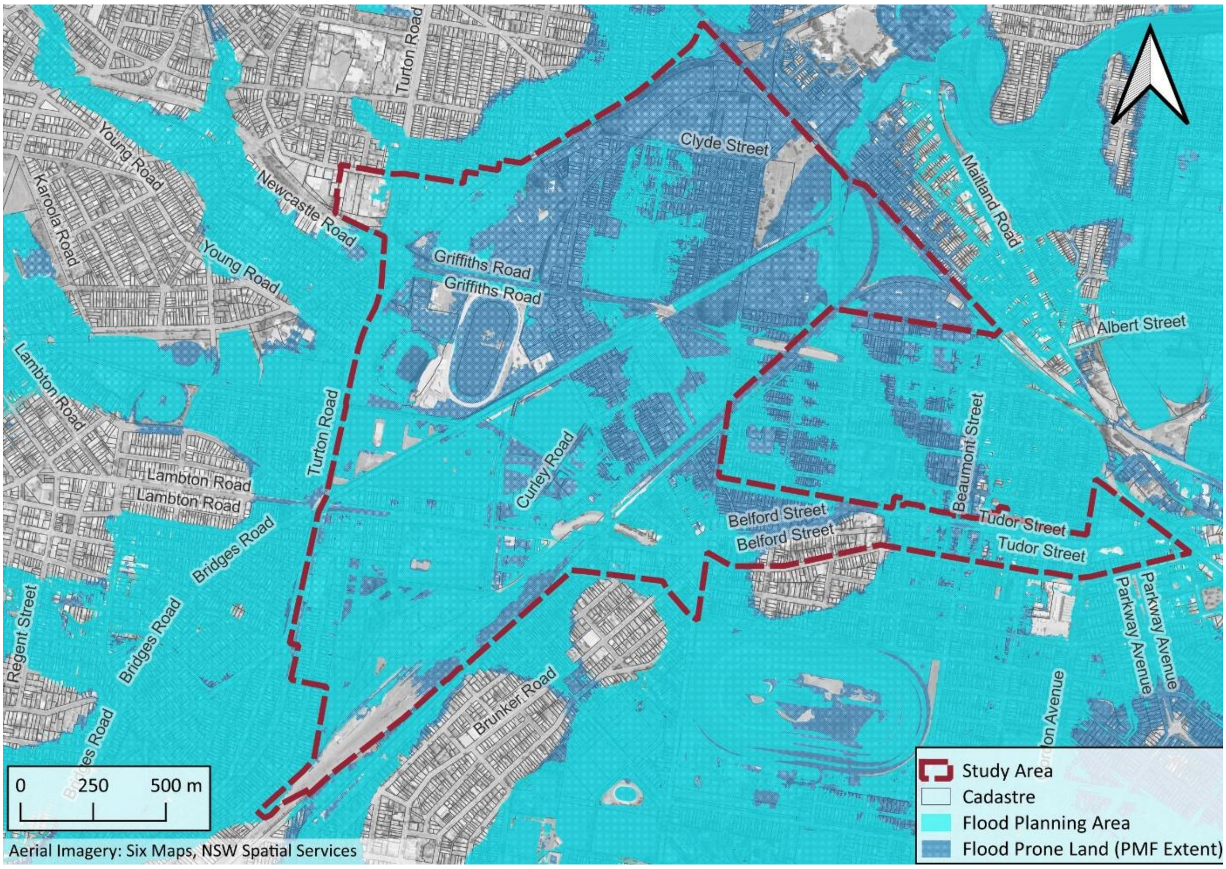

Figure 6-5. Post-Development Flood Planning Area

6.5 Flood Modification Works Staging

A preliminary staging plan has been prepared by DPHI and Cox Architects (dated 22/04/24) and is shown in **Figure 6-6**. **Table 6-4** summarises the structural flood modification works required to support each stage of the Precinct rezoning.

It should be noted that no modelling has been undertaken for Stages 1 to 3 of Precinct rezoning/development; however, this has been undertaken for the first moves staging (**Section 6.5.1**). It is recommended that modelling of each stage is undertaken in subsequent phases of the project or for development applications associated with each stage to confirm the flood behaviour and impacts associated with the staged approach.

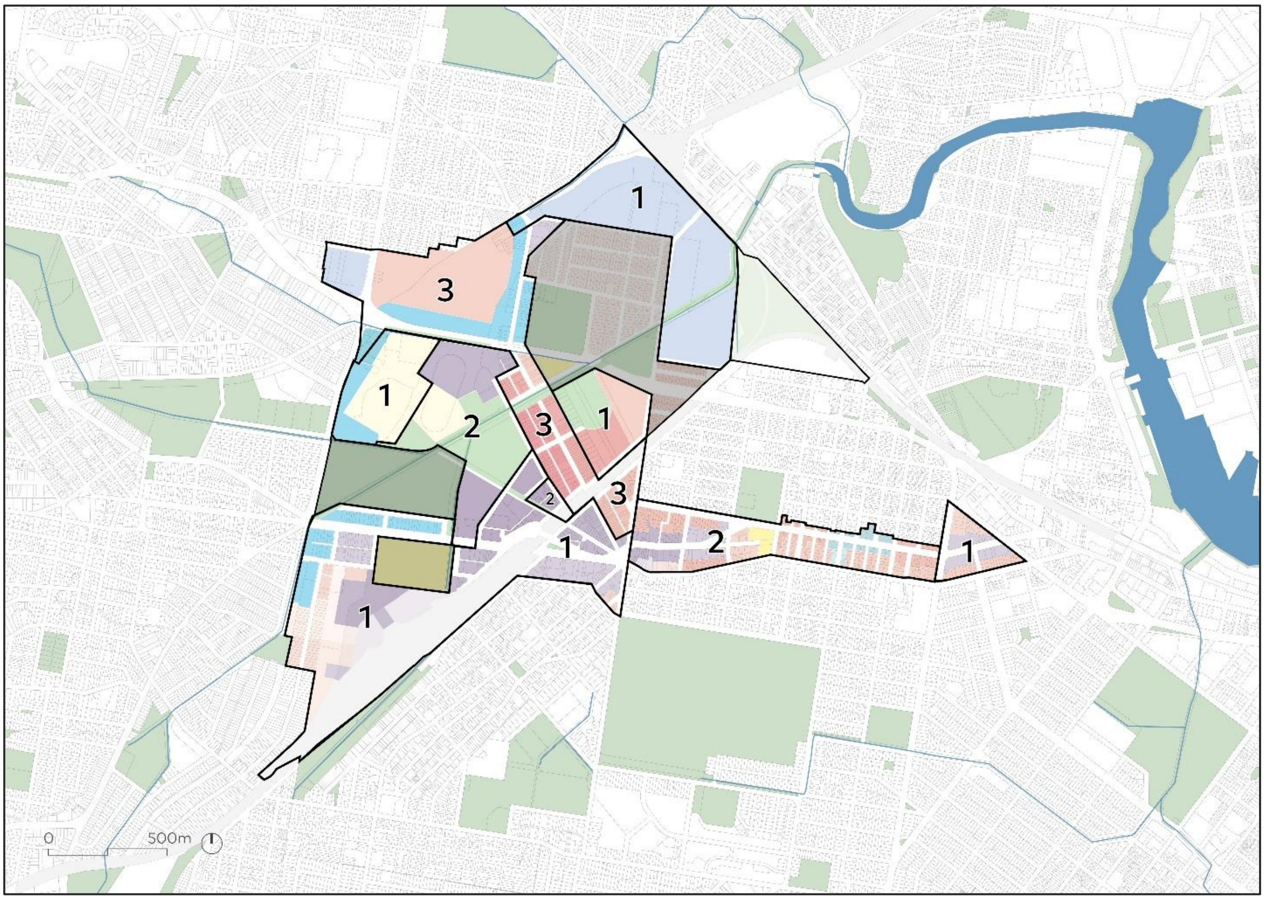

Figure 6-6. Proposed Precinct Staging (DPHI/Cox, 2024)

Table 6-4. Flood Modification Works Staging

Precinct Stage	Required Supporting Flood Mitigation Works	Location (from Figure 6-1)
Stage 1	• Styx Creek widening/naturalisation works from downstream of Mackie Avenue to downstream of Lambton Road and from downstream of Broadmeadow Road to the northern Styx Creek works extent.	6
	• Construction of all external-to-Precinct flood storages.	15, 16 and 17
	• Construction of the proposed diversion channel along the southern boundary between the Broadmeadow Locomotive Precinct and Styx Creek, including the cross-drainage culvert under Kings Road and local road and lot raising immediately north of this location.	7
	• Partial Lambton Road raising and upstream drainage upgrade works (refer **Section 6.5.1**).	5
	• Filling of the mixed-use area upstream of Lambton Road.	5

Precinct Stage	Required Supporting Flood Mitigation Works	Location (from Figure 6-1)
	• Construction of the proposed detention/flood storage area in the southern portion of the Knights Centre of Excellence site, including the downstream Styx Creek constriction.	11
	• Construction of the proposed 2.4 ha detention/flood storage area immediately west of McDonald Jones Stadium, including the downstream Ker-rai Creek constriction.	12
	• Griffiths Road raising and culvert upgrade works	3
	• Hamilton North channel and drainage upgrades.	2
	• Construction of the Smith Park detention/flood storage area, including inlet and outlet works.	4
	• Filling of the proposed Stage 1 residential portions around the Newcastle Showground site.	9
	• Newcastle Showground drainage upgrade works, including the proposed overland flow path between the railway line and inner oval of the Showground.	9
	• Construction of the proposed detention/flood storage area north of the Showground perimeter road.	9
	• Construction of the proposed detention/flood storage area around the north-western railway junction, including connecting culverts, upstream drainage works and downstream Styx Creek constriction.	14
	• Trunk drainage upgrades downstream of Tudor Street.	10
Stage 2	• Styx Creek widening/naturalisation works from downstream of Lambton Road to downstream of Broadmeadow Road.	1
	• Completion of Lambton Road raising and upstream drainage upgrade works.	5
	• Construction of the proposed detention/flood storage area in the Magic Park and Westpac Rescue Helicopter sites, including the downstream tributary constriction.	13
	• Filling of the proposed residential and mixed-use areas north of Belford Street, including the corresponding road raising.	8
	• Tudor Street channel and drainage upgrade works.	10
	• Construction of the relief culverts under the railway line, west of Graham Road.	8
Stage 3	• Filling of the proposed Stage 3 residential area between Belford Street and the railway.	8
	• Filling of the proposed Stage 3 residential area west of the Newcastle Showground site.	9
	• Construction of the proposed 0.6 ha detention/flood storage area immediately west of McDonald Jones Stadium.	12

6.5.1 First Moves Staging

A first moves staging plan has been developed by DPHI and Cox Architects which identifies a number of large Government-owned lots that will be the first parcels of land subject to rezoning. The proposed first move sites and staging is shown in **Figure 6-7**.

Modelling was undertaken to determine the flood modification measures required for Stages 1b, 1c and 1d, with the only management measures required in Stage 1a being those nominated in the *Flood Impact Assessment – Broadmeadow Locomotive Precinct* (BMT, 2023). These first moves mitigation measures are shown in **Figure 6-8** (Stages 1B and 1C) and **Figure 6-9** (Stage 1D). Flood depths and elevations for the 1% AEP in 2050 and PMF events are shown in **Maps RG-03-100** to **RG-03-105**, attached in **Appendix C**.

Given the first move sites are within Stage 1 which is expected to be rezoned within 10 years, the present day 1% AEP event (with no rainfall or sea level rise increase) was used for assessing flood impacts associated with each stage of the first moves (**Maps RG-03-110** to **RG-03-112** in **Appendix C**).

The results of the first moves modelling suggest that a significant proportion of the overall mitigation works will need to be constructed during Stage 1B to mitigate the increases in flows associated with the upstream Styx Creek works and Lambton Road bridge widening. If these widening works were to be delayed until future stages, the Basketball Stadium and Newcastle Showground sites would be subject to increased flood risk when compared to the ultimate scenario and any filling to meet flood planning level requirements would have adverse flood impacts on adjacent sites.

The flood impact mapping indicates that the proposed staging of flood mitigation infrastructure is generally sufficient to mitigate 1% AEP impacts on private property external to each first moves site. Minor impacts (less than 0.1m) are observed upstream of the railway line along the eastern boundary of the Precinct. These impacts could be eliminated through temporary drainage works or upgrade of additional sections of the HWC trunk drainage line at this location during the first moves stage. Similar to the ultimate scenario, artificial impacts are present at a number of locations due to the flood model’s local inflow methodology.

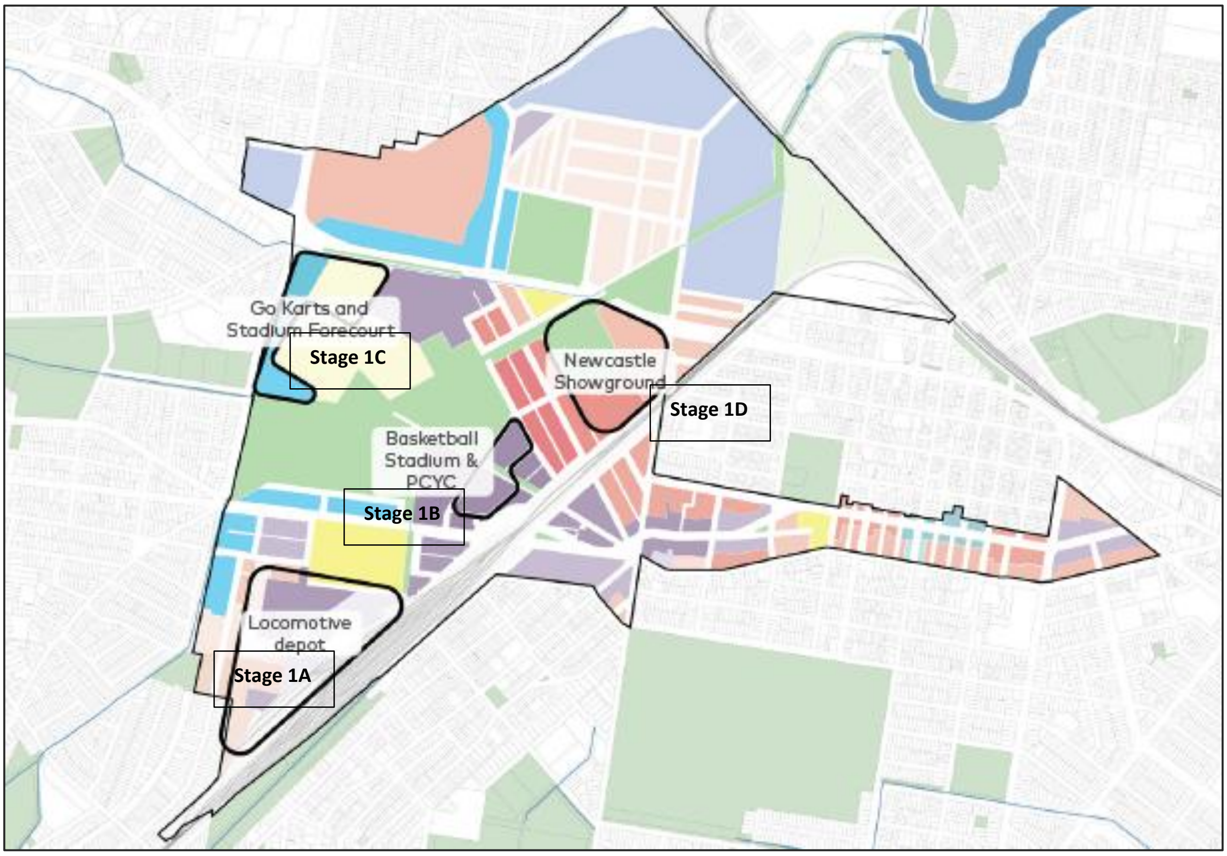

Figure 6-7. Proposed First Moves Staging (Source: DPHI/Cox, 2024)

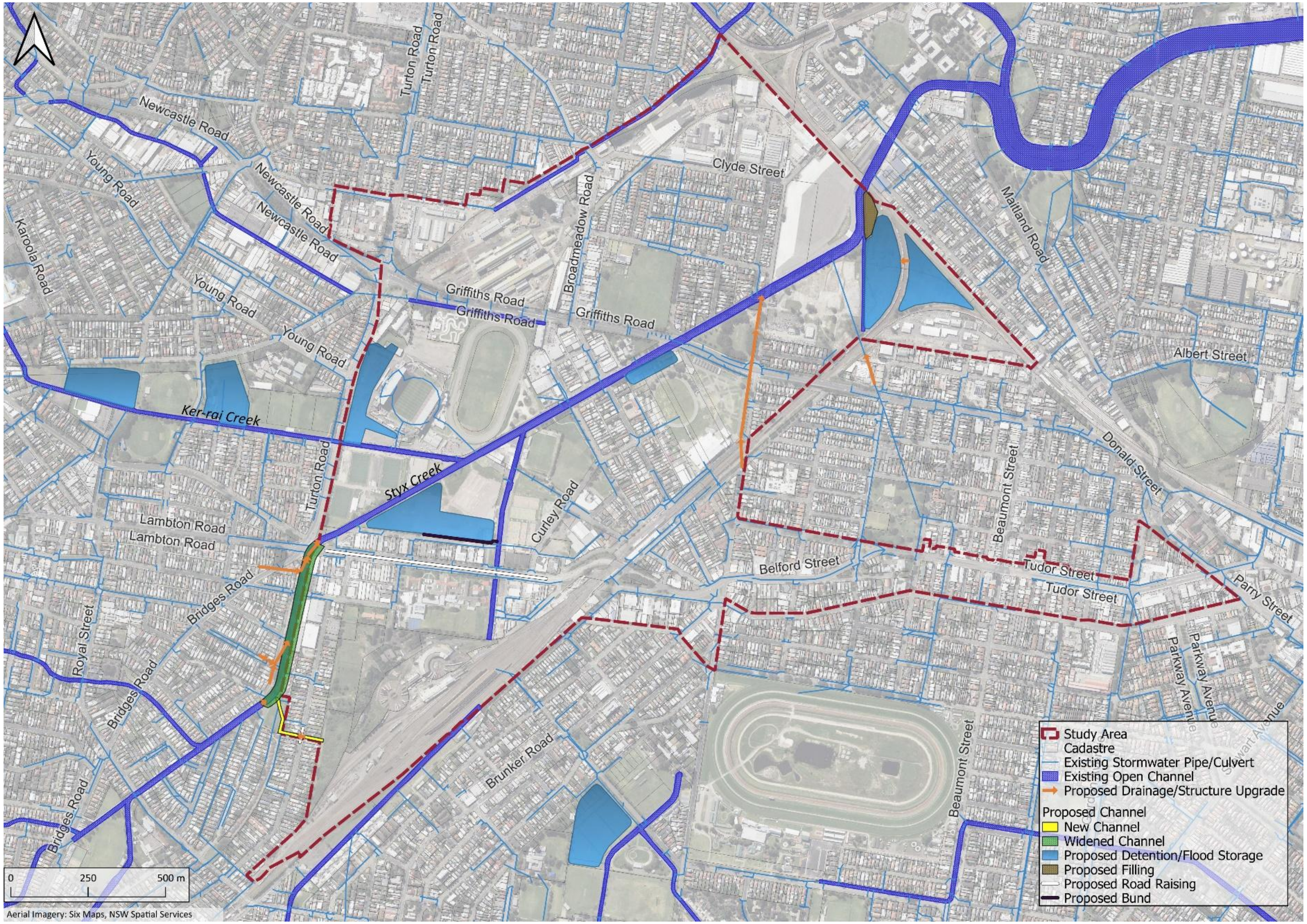

Figure 6-8. Stage 1B/1C Flood Modification Measures

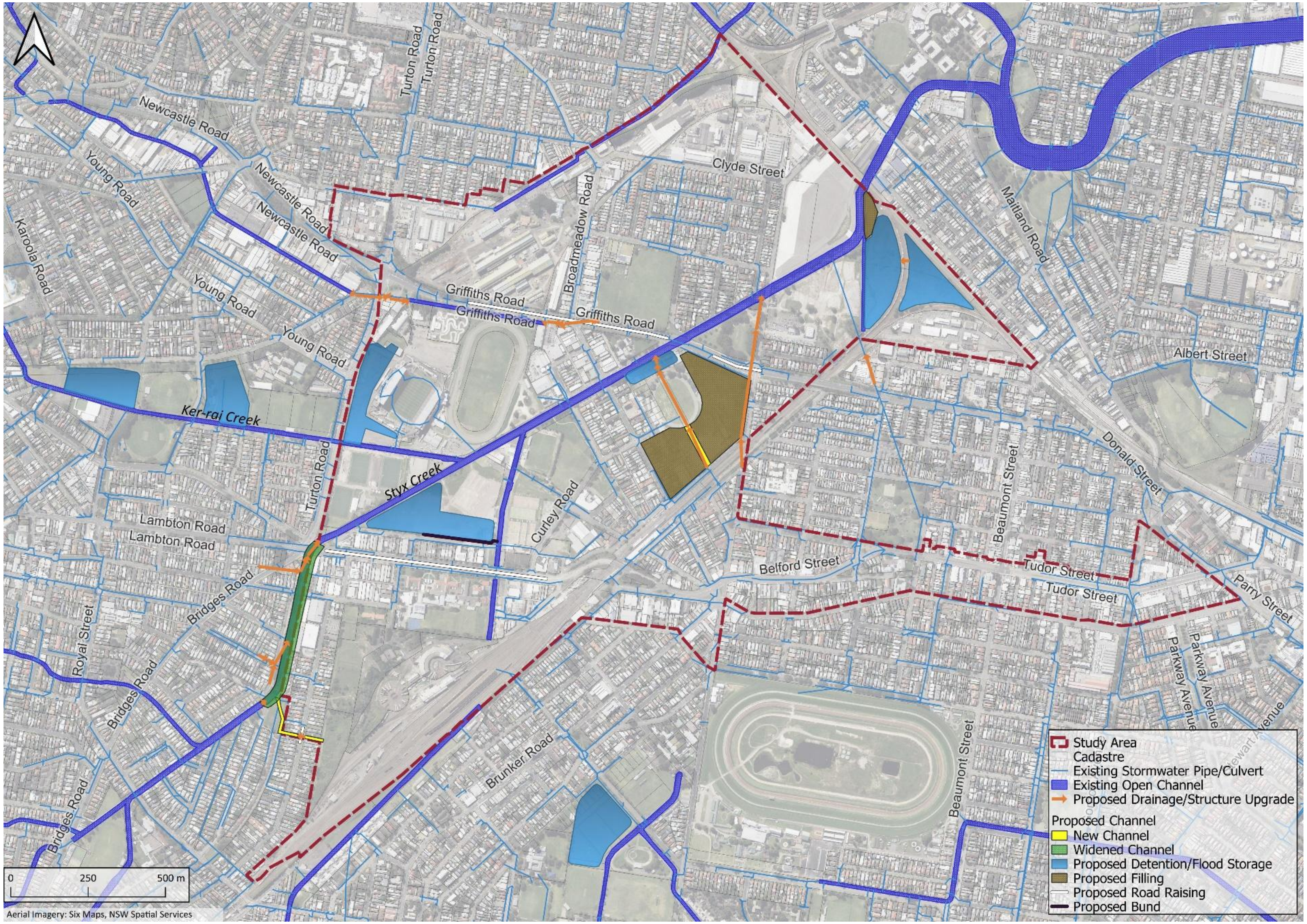

Figure 6-9. Stage 1D Flood Modification Measures

6.5.1.1 Alternate Racecourse Basin Strategy

Additional modelling was undertaken to determine the impact on required first moves flood modification works (up to Stage 1D) if the alternate racecourse basin strategy (**Section 6.1.3.1**) was adopted, with this basin being constructed during Stage 1B.

This option requires a lower overall number of detention basins to reduce flows to existing levels at the Precinct outlet due to the substantial flow attenuation provided by the proposed racecourse storage. Required first moves flood modification works under this strategy are shown in **Figure 6-10**. Flood depth (**Maps RG-03-106** and **RG-03-107**) and impact maps (**Map RG-03-113**) are attached in **Appendix C**.

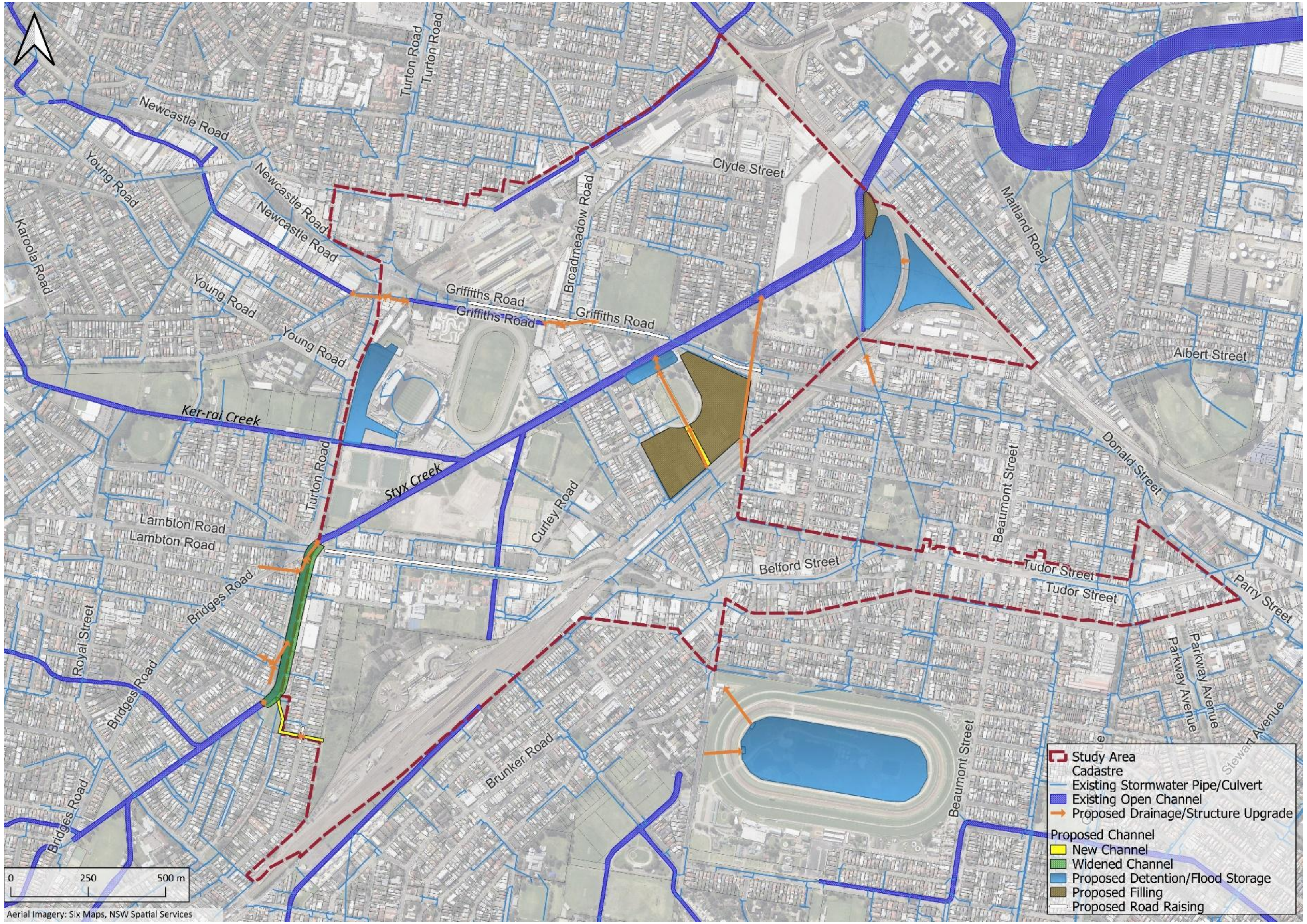

Figure 6-10. Stage 1D Flood Modification Measures – Racecourse Basin Strategy

7 Water Cycle Management Assessment

7.1 Water Cycle Management Strategy

The water cycle management strategy for the Precinct has been developed with consideration to feedback provided by Council, DPHI and relevant consultants during the project Enquiry by Design workshops and subsequent coordination meetings.

The adopted strategy comprises the retention of Council’s on-lot volumetric discharge controls and pollutant reduction targets stipulated in Section C4 of Council’s DCP (refer **Section 3.2.2**) coupled with regional stormwater treatment interventions to improve overall catchment water quality outcomes compared to existing conditions.

Modelling of lot-scale measures has not been undertaken as part of this Precinct-wide assessment as it will be the responsibility of individual developers to demonstrate that future on-lot stormwater discharge controls are compliant with the Newcastle DCP 2023.

Proposed regional interventions are summarised in **Section 7.1.1** and **7.1.2**. It is proposed that these measures are constructed during Stage 2 (refer **Figure 6-6**) of the Precinct development in conjunction with the proposed flood storage works at Magic Park (item 13 from **Table 6-1**). No works are required for the proposed first-moves.

7.1.1 Gross Pollutant Trap Upgrade

During a site inspection undertaken by Rhelm engineers on 4 May 2023, it was identified that the diversion weir (**Figure 7-1**) of the open GPT adjacent to the Westpac Rescue Helicopter site is in poor condition and may not be effective at diverting smaller gross pollutants into the storage bay. As such, it is proposed that this diversion weir is replaced with a Baramy-style vane arrangement (**Figure 7-2**) of equivalent height (approximately 0.4m) to improve pollutant capture whilst still allowing for drainage of the storage bay following rainfall events.

There is also opportunity to modify the GPT outlet arrangement to provide a low flow diversion pipe to the proposed wetland downstream (refer **Section 7.1.1**) rather than providing an offtake further downstream.

Figure 7-1. Existing Diversion Weir (Source: Rhelm, 2023)

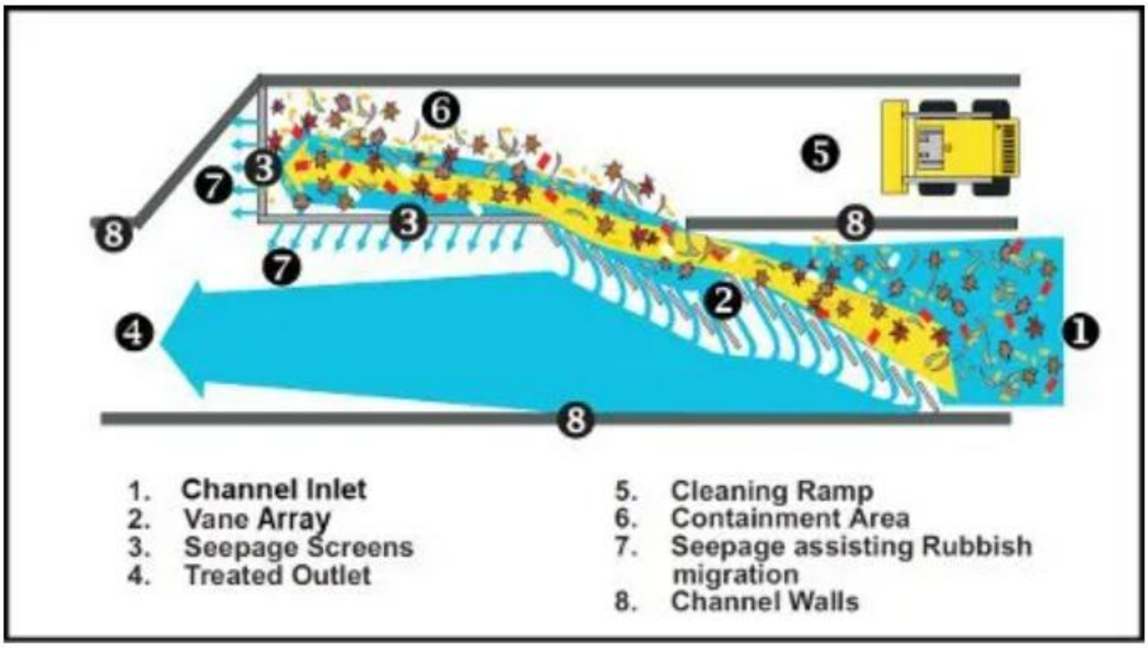

Figure 7-2. Potential Diversion Weir Arrangement (Source: Baramy, 2023)

7.1.2 Regional Wetland

An approximately 2.6 ha constructed wetland area is proposed in the north-western portion of Magic Park, within the broader flood storage/open space area at this location (refer **Section 6.1.3**). In addition to providing water quality benefits, this measure will provide a habitat for a range of fauna and also address Connecting to Country objectives identified in the Enquiry by Design workshops by incorporating a wetland area intended to be reflective of the local environment (prior to urbanisation). The proposed infrastructure would require construction prior to Stage 2 when the dual use wetland (flood mitigation and water quality improvement) is needed to allow for Stage 2 development.

The proposed wetland would include the following:

- 0.2 ha inlet sediment pond,
- 1.7 ha macrophyte zone consisting of marsh and open water components,
- Macrophyte wetland zone outlet control pit, outlet pipe and internal balance pipes,
- 0.6m high diversion weir and 2.1m wide x 0.6m high low flow diversion culvert between the tributary and inlet sediment pond,
- Lining of the sediment pond and macrophyte zone with an impermeable membrane to prevent the ingress of potentially contaminated groundwater, and
- Minimum 3m wide maintenance access track around the wetland perimeter.

The proposed layout is shown in **Figure 7-3**.

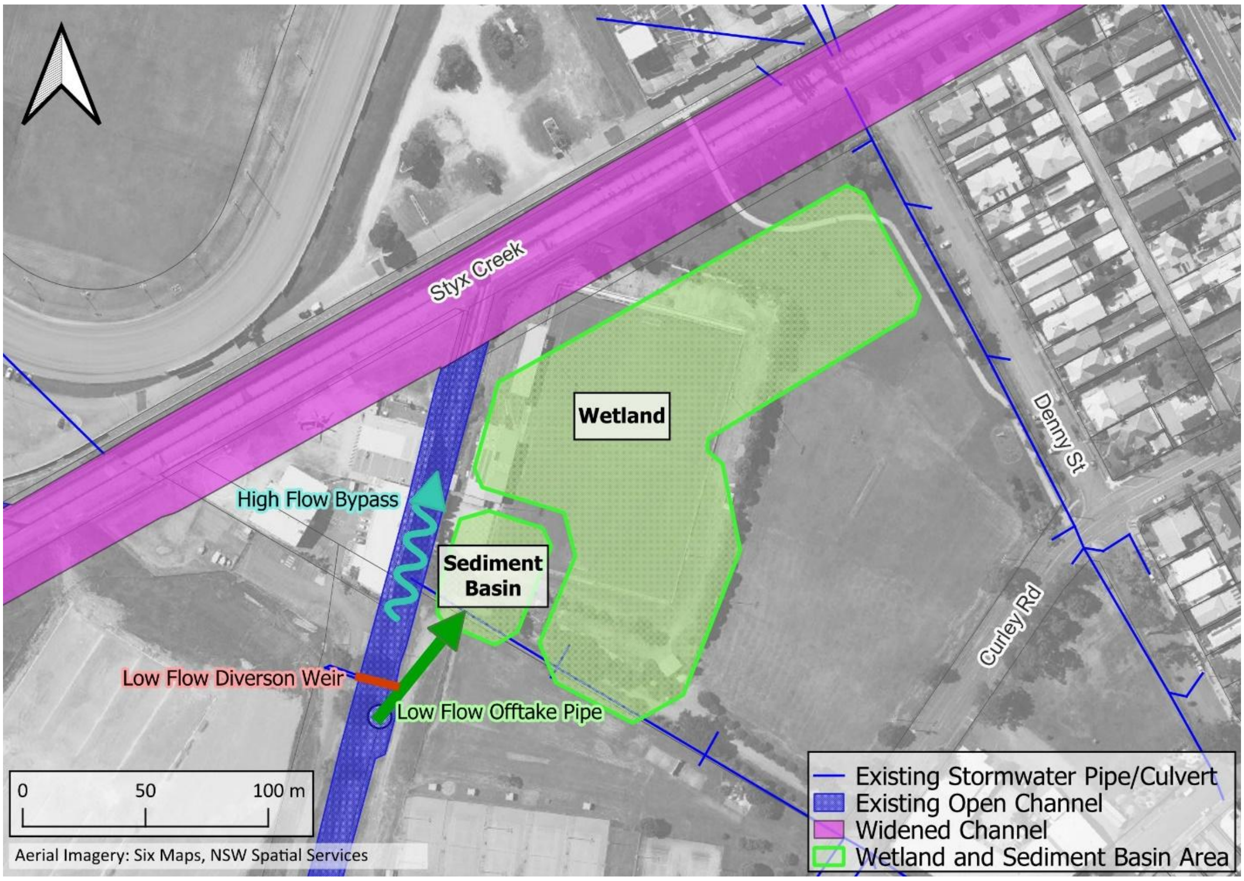

Figure 7-3. Proposed Regional Wetland Conceptual Layout

7.1.3 Stormwater Harvesting

A regional stormwater harvesting scheme for Precinct open space irrigation was considered to reduce the reliance on potable water and assist in meeting sustainability objectives. However, this has not been included in the Precinct water cycle management strategy due the infrastructure costs associated with the storage, treatment and reticulation of recycled stormwater given the significant scale required for the proposed flood modification measures (refer **Section 6.1.3**).

It is recommended that irrigation servicing of proposed open space areas is compatible with a potential recycled water connection should a harvesting and re-use (or alternate recycled water) scheme become viable in the future. This may become more feasible if the option for using the Newcastle Racecourse site (refer **Section 6.1.3.1**) for flood mitigation becomes available in the future.

7.2 Post-Development Scenario MUSIC Modelling

7.2.1 Source Node Updates

Source node types and areas were updated in the post-development MUSIC model to reflect the proposed land use zoning.

All other source node parameters were kept consistent with the base case model.

7.2.2 Treatment Nodes

Two additional treatment node types were incorporated into the post-development scenario MUSIC model:

- Sedimentation basin, and
- Pond (wetland).

Details of these treatment nodes are provided in the following sections. Adopted parameters for the GPT treatment nodes remained consistent with the base case model and Council's MUSIC-link.

7.2.2.1 Sedimentation Basin

A default sediment basin node was used to represent the sediment basin attached to the constructed wetland. Modelled volumes were set at 80% of the overall permanent pool volume to account for sedimentation in the base. The high flow bypass was set at the flowrate required to keep velocities in the downstream wetland (**Section 7.2.2.2**) sufficiently low. Key sediment basin parameters are summarised in **Table 7-1**.

Table 7-1. Sediment Basin Parameters

Parameter	Value
Low Flow Bypass (m^3/s)	0
High Flow Bypass (m^3/s)	1.35
Surface Area (m^2)	1,600
Extended Detention Depth (m)	0.35
Permanent Pool Volume (m^3)	1,920
Exfiltration Rate (mm/hr)	0
Evaporative Loss as % of PET	75
Notional Detention Time (hrs)	1.25

7.2.2.2 Pond (Wetland)

Given the macrophyte zone overflow will be located at the downstream end of the proposed constructed wetland, pond treatment nodes with k and C* values adjusted to match those of a wetland were used in lieu of the default wetland nodes where the overflow is assumed to be located upstream of the macrophyte zone. The high flow bypass rate for the wetlands has been set at a value to limit design velocities to a maximum of 0.05m/s in the shallow marsh zones during frequent events as opposed to conveying full 4EY flows through the macrophyte zone.

Key wetland parameters are summarised in **Table 7-2**.

Table 7-2. Wetland Parameters

Parameter	Value
Upstream Catchment Area (Ha)	230
Low Flow Bypass (m^3/s)	0
High Flow Bypass (m^3/s)	1.35
Surface Area (m^2)	17,000
Extended Detention Depth (m)	0.35
Permanent Pool Volume (m^3)	6,800
Exfiltration Rate (mm/hr)	0
Evaporative Loss as % of PET	125
Notional Detention Time (hrs)	53.3

7.2.3 Results

Table 7-3 below summarises the results of the MUSIC water quality assessment for the post-development scenario, including the percentage reduction compared to untreated catchment runoff associated with the regional GPTs and proposed wetlands. It should be noted that the results do not account for proposed on-lot treatment within the Precinct and will slightly under-represent the potential improvements in catchment water quality associated with the proposed rezoning. This allows for conservative comparison against existing conditions where on-lot discharge controls are enforced for new development, but would not be present on a number of older development sites across the Precinct (and broader catchment) and were thus excluded from the base case modelling (**Section 4.3.3**).

Table 7-3. Post-Development MUSIC Model Results

Pollutant	Post-Development Un-Treated Loads (kg/yr)	Precinct (un-treated) Loads (kg/yr)	Post-Development Outflow Loads (kg/yr)	Percentage Reduction %
Total Suspended solids (TSS)	1,970,000	375,000	1,740,000	11.8
Total Phosphorus (TP)	3,460	636	3,190	7.6
Total Nitrogen (TN)	26,200	4,760	25,600	2.3
Gross Pollutants	341,000	62,000	273,000	19.9

The MUSIC results shown in **Table 7-3** indicate that the incorporation of the proposed wetland results in slight water quality improvements compared to existing conditions (**Section 4.3.3**), with TSS, TP and TN levels in the order of 2-7% lower than existing conditions from an overall catchment perspective. These levels would be further reduced with the proposed on-lot treatment in accordance with the Newcastle DCP 2023.

7.3 Maintenance of Stormwater Management Measures

The proposed regional stormwater treatment interventions would be owned and maintained by Council; whilst the maintenance of on-lot measures would be the responsibility of individual landowners. Maintenance of all stormwater management measures should be undertaken in accordance with the *Guidelines for Maintenance of Stormwater Treatment Measures* (Stormwater NSW, 2020).

At a minimum, maintenance inspections of the proposed regional treatment measures should be undertaken at a minimum of every 3-6 months and following significant rainfall events. Results of the post-development MUSIC modelling (**Section 7.2**) indicate that the upgraded GPT and wetland sediment pond will accumulate captured pollutants at a rate of approximately 200m^3/year and 50m^3/year, respectively. This rate of accumulation would not result in required cleanout frequencies exceeding those considered typical for such devices.

Future detailed design of the stormwater management measures would be accompanied by an Operation and Maintenance Plan detailing maintenance procedures, frequencies and reporting requirements.

8 Conclusion and Recommendations

A flooding and water cycle management strategy has been developed for the Broadmeadow Place Strategy and proposed first-move rezoning.

A flood impact and risk assessment revealed that, despite the introduction of a significant additional population to the floodplain, flood impacts and risks can be managed by:

- Enforcing appropriate development controls to ensure future buildings are flood-resilient with flood refuge above PMF levels,
- Requiring future development to include on-lot detention to limit post-development flows to pre-development levels,
- Establishing a flood education program specific to the Precinct and consistent with Section 7.3.1 of the *Newcastle City-Wide Floodplain Risk Management Study and Plan* (BMT WBM, 2012),
- Expanding Styx Creek and associated bridge structures to have sufficient capacity for 1% AEP in 2050 flow conveyance,
- Adopting a shelter in place strategy and limiting the PMF duration of inundation (for flood hazard exceeding a H1 classification) to a maximum of six hours for areas of proposed up-zoning/densification and along key emergency services access routes (Griffiths Road and Lambton Road),
- Providing regional flood/storage detention areas within flood-compatible land uses to mitigate downstream increases in flows caused by improved flood conveyance through the Precinct, and
- Upgrading key drainage lines to reduce the frequency and severity of overland flooding within the Precinct.

This approach not only allows for appropriate flood compatible development within the Precinct. It also reduces flood risk for existing residential land use for the local area including areas subject to frequent flooding such as Hamilton North, New Lambton and Adamstown.

Water cycle management objectives for the Precinct can be achieved by:

- Retaining Council's on-lot volumetric discharge controls and pollutant reduction targets stipulated in Section C4 of the Newcastle DCP 2023,
- Upgrading the open GPT adjacent to the Westpac Rescue Helicopter site, and
- Providing a regional treatment wetland at the existing Magin Park site to improve water quality compared to existing conditions.

The following recommendations should be considered with the development of further iterations of the Precinct layout plan and future design phases of the Project:

- Maintaining the existing land zoning and flood storage over the Council depot site at the corner of Griffiths and Turton Road or incorporating further structural flood mitigation works into the site design to eliminate negative flood risk impacts,
- Providing a sufficiently sized Styx Creek corridor to suit required conveyance corridor width plus an allowance for ancillary landscaping features,
- Investigating potential refinements to the sizing of structural flood mitigation measures including optimisation of earthworks across public and private open spaces proposed to be used for flood

storage, with the aim of ensuring these facilities can maintain public safety and their current function,

- Further flood modelling to confirm flood behaviour and impacts associated with each stage of the Precinct rezoning/development, and
- Further investigation into the feasibility of the alternate Newcastle Racecourse detention basin strategy.

9 References

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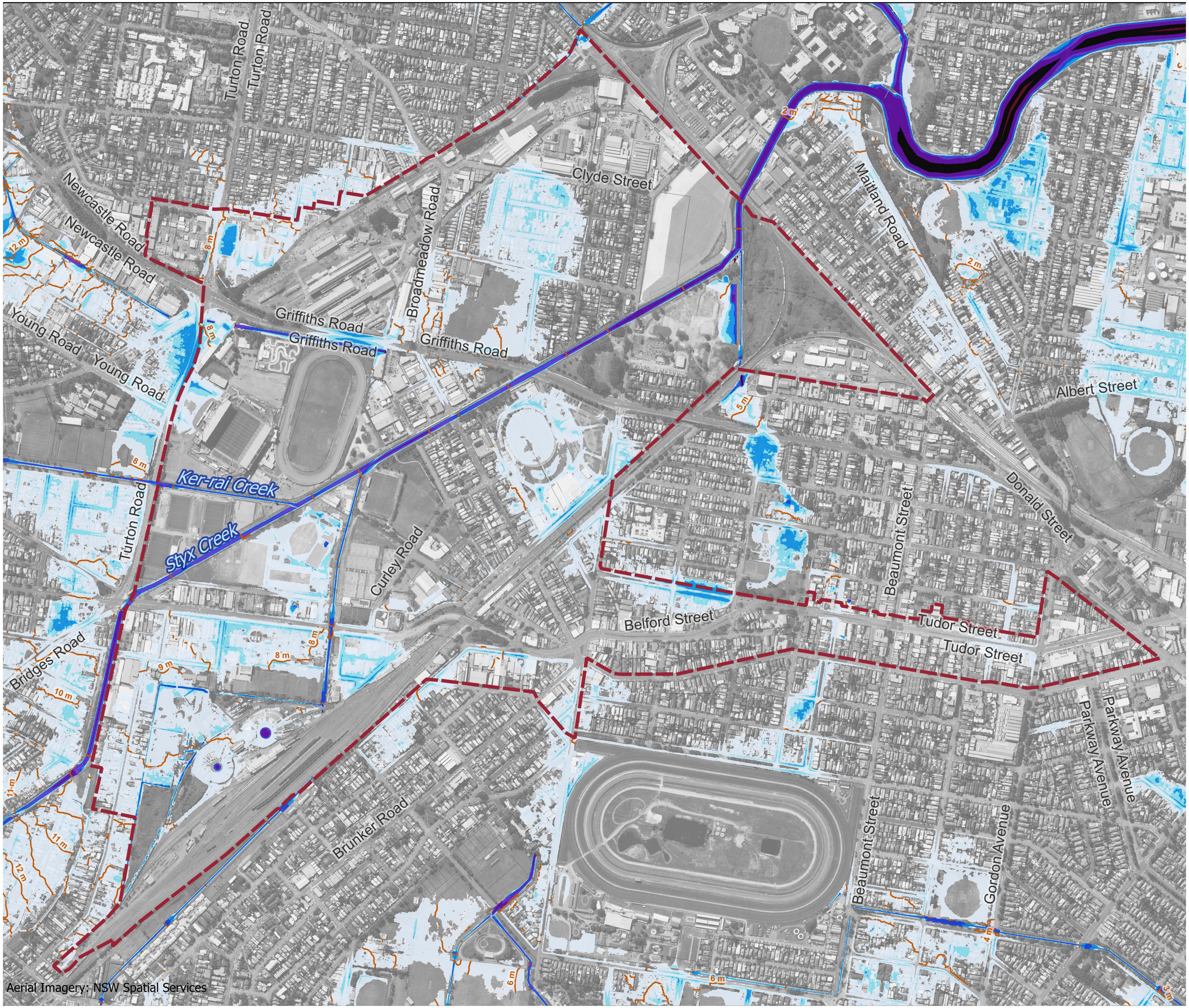
Rhelm

Appendix A

Existing Scenario Flood Mapping



N
W E
S

RG-01-100

Existing 10% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

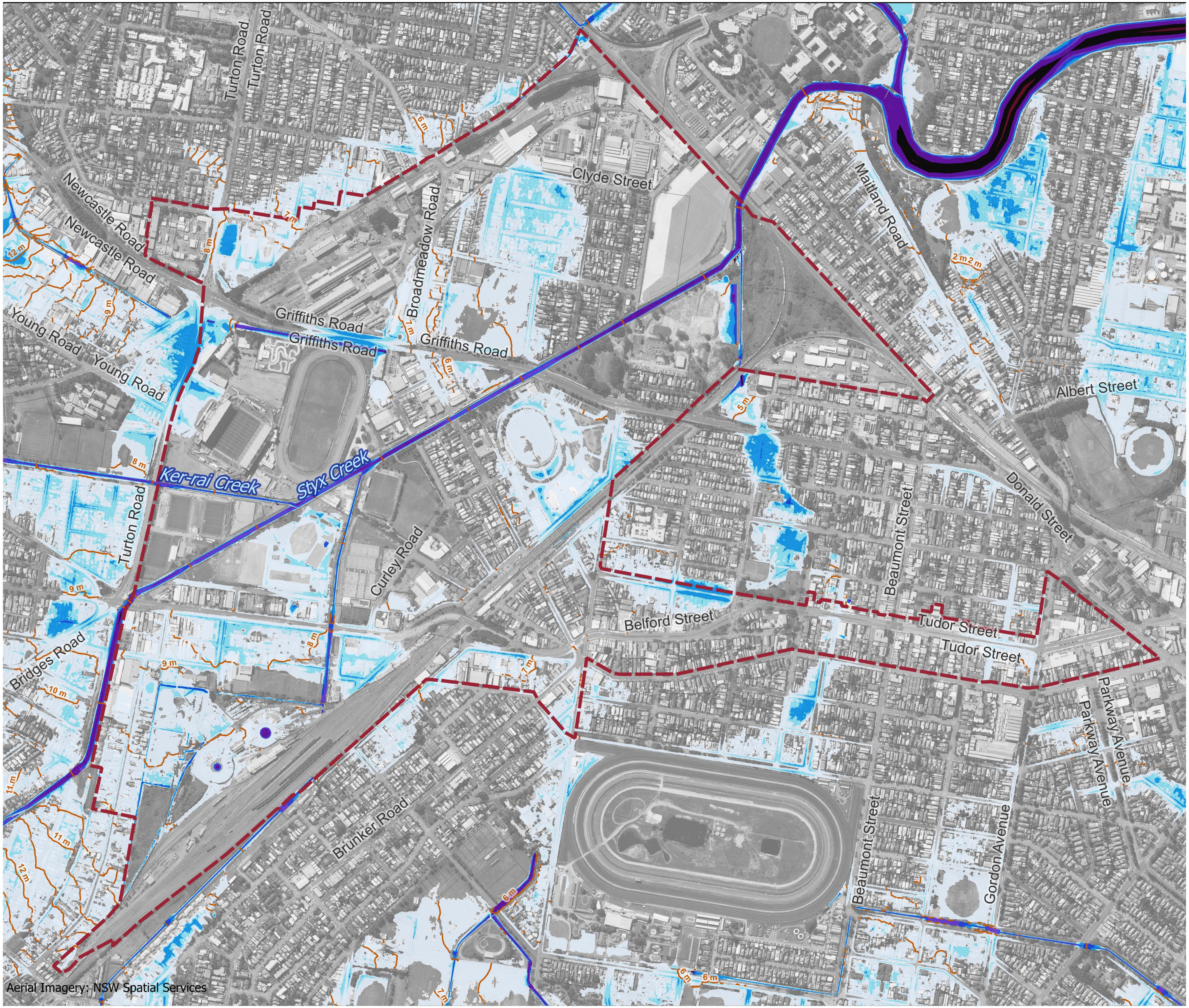
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-101

Existing 5% AEP Peak Flood Depth and Elevation

Legend

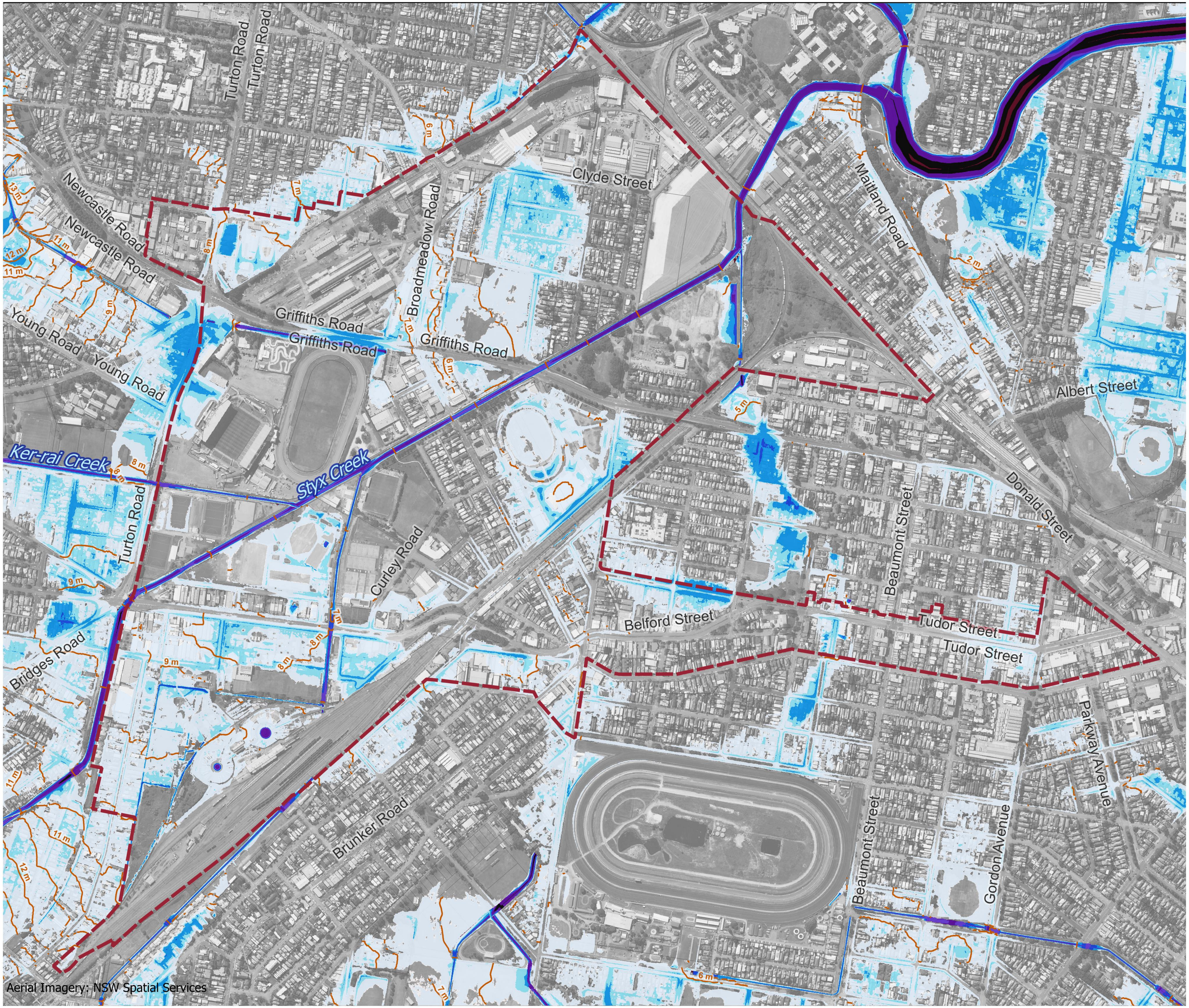
Study Area

Cadastre

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-102

Existing 2% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

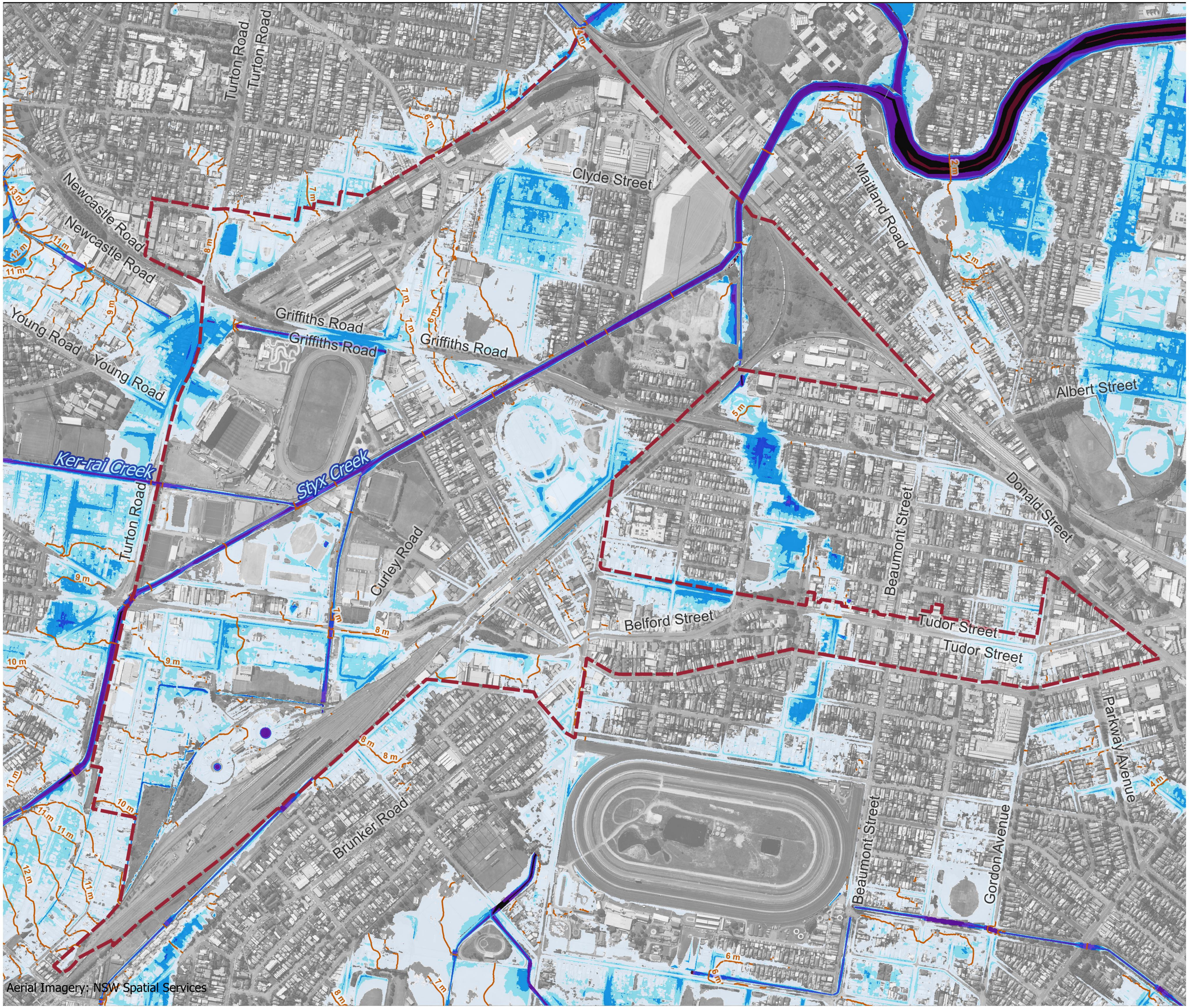
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-103

Existing 1% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

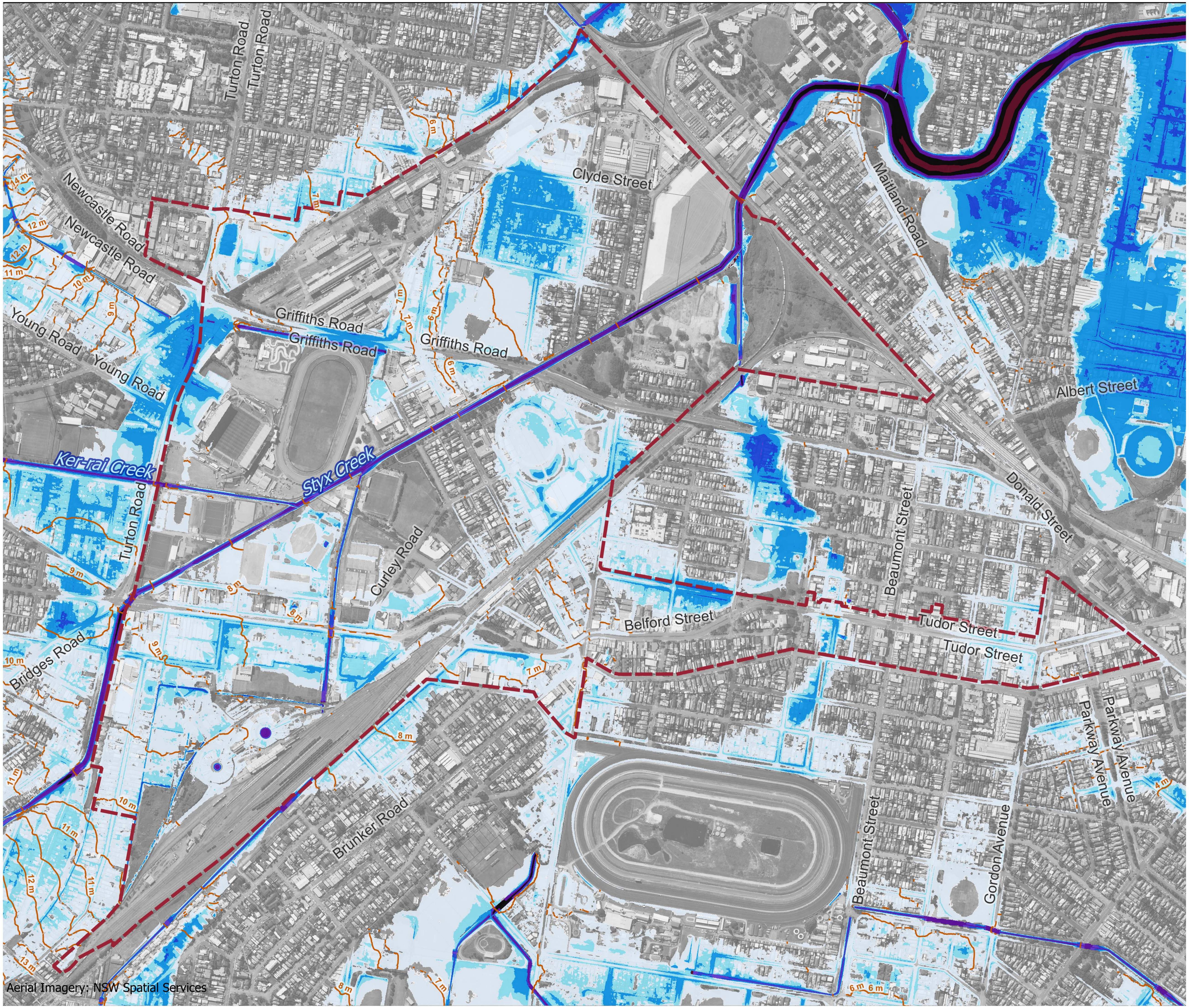
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-104

Existing
0.5% AEP Peak Flood Depth and Elevation

Legend

Study Area
Cadastre
1m Water Level Contours

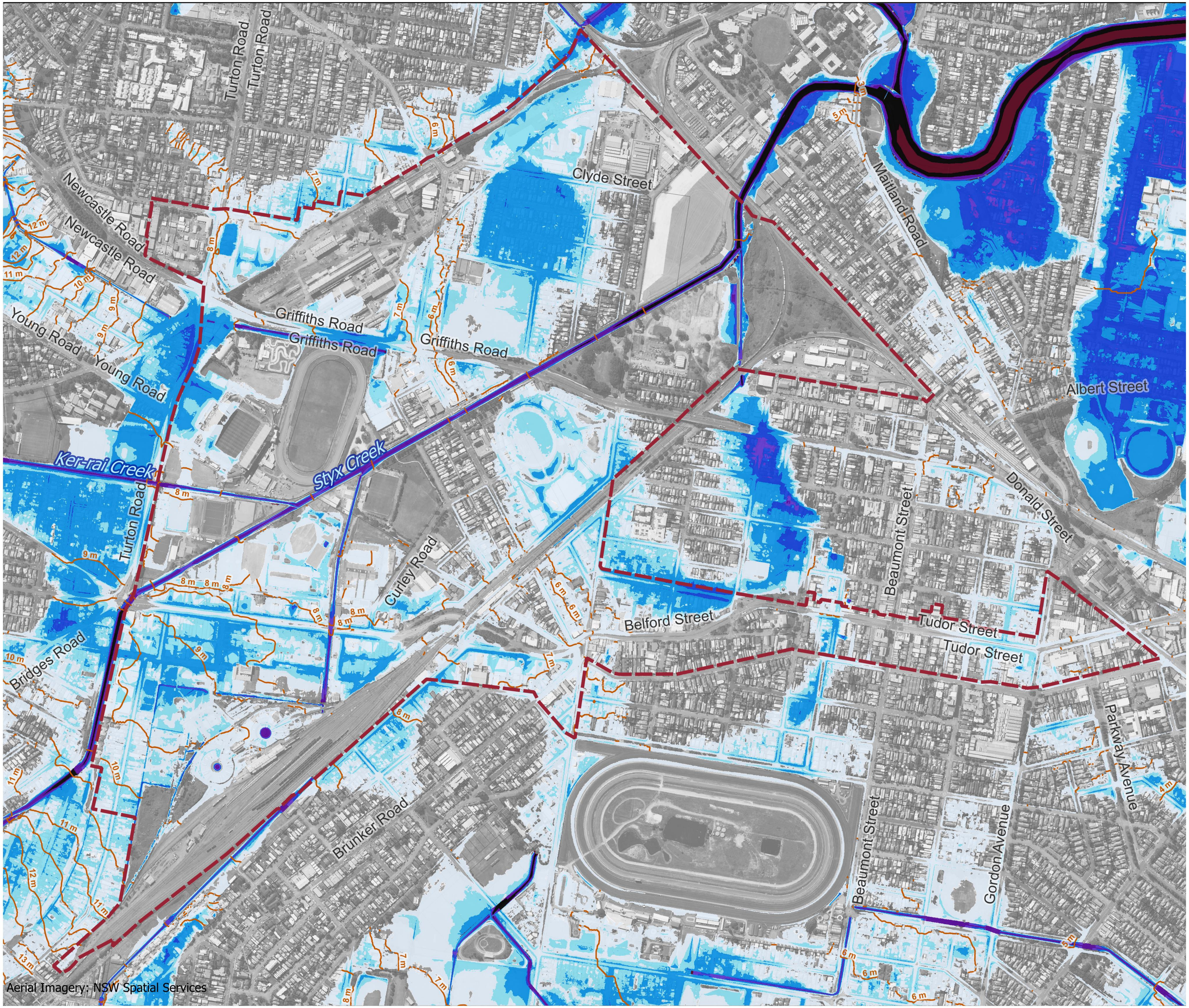
Peak Flood Depth (m)

<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
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RG-01-105

Existing
0.2% AEP Peak Flood Depth and Elevation

Legend

Study Area
Cadastre
1m Water Level Contours

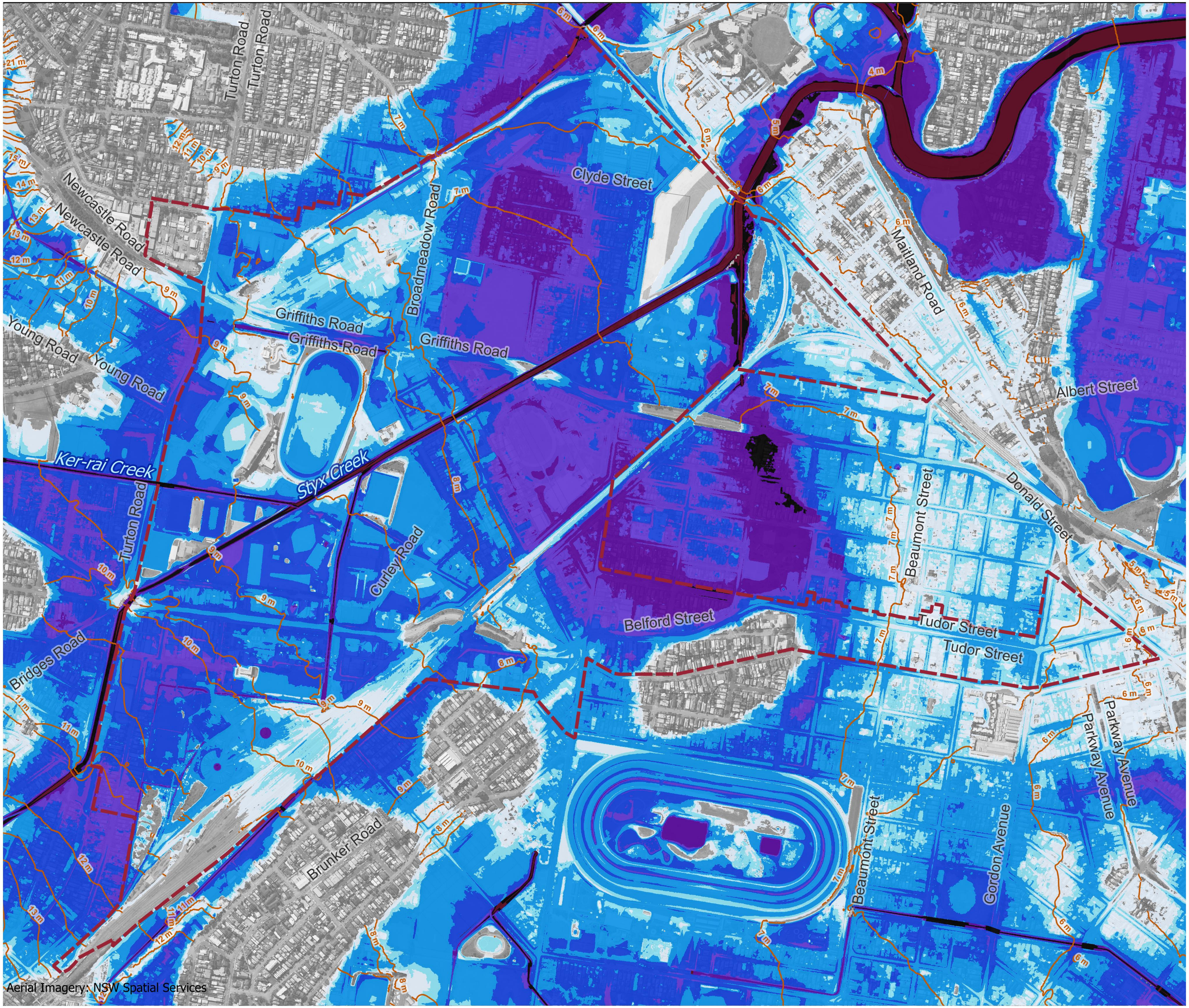
Peak Flood Depth (m)

<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-106

Existing PMF Peak Flood Depth and Elevation

Legend

Study Area

Cadastre

1m Water Level Contours

Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm

N
W E
S

RG-01-110

Existing 10% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

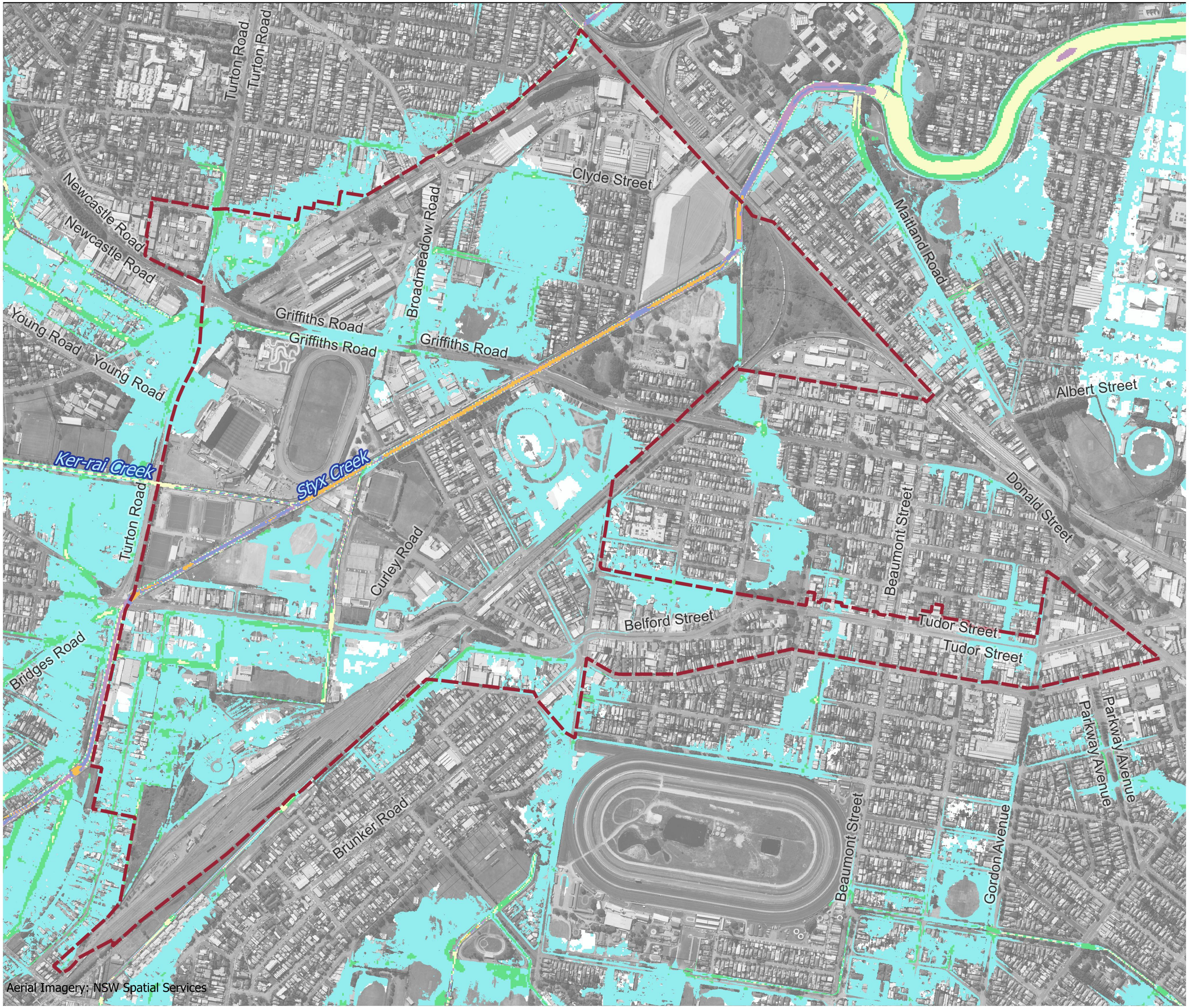
Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-111

Existing
5% AEP Peak Flood Velocity

Legend

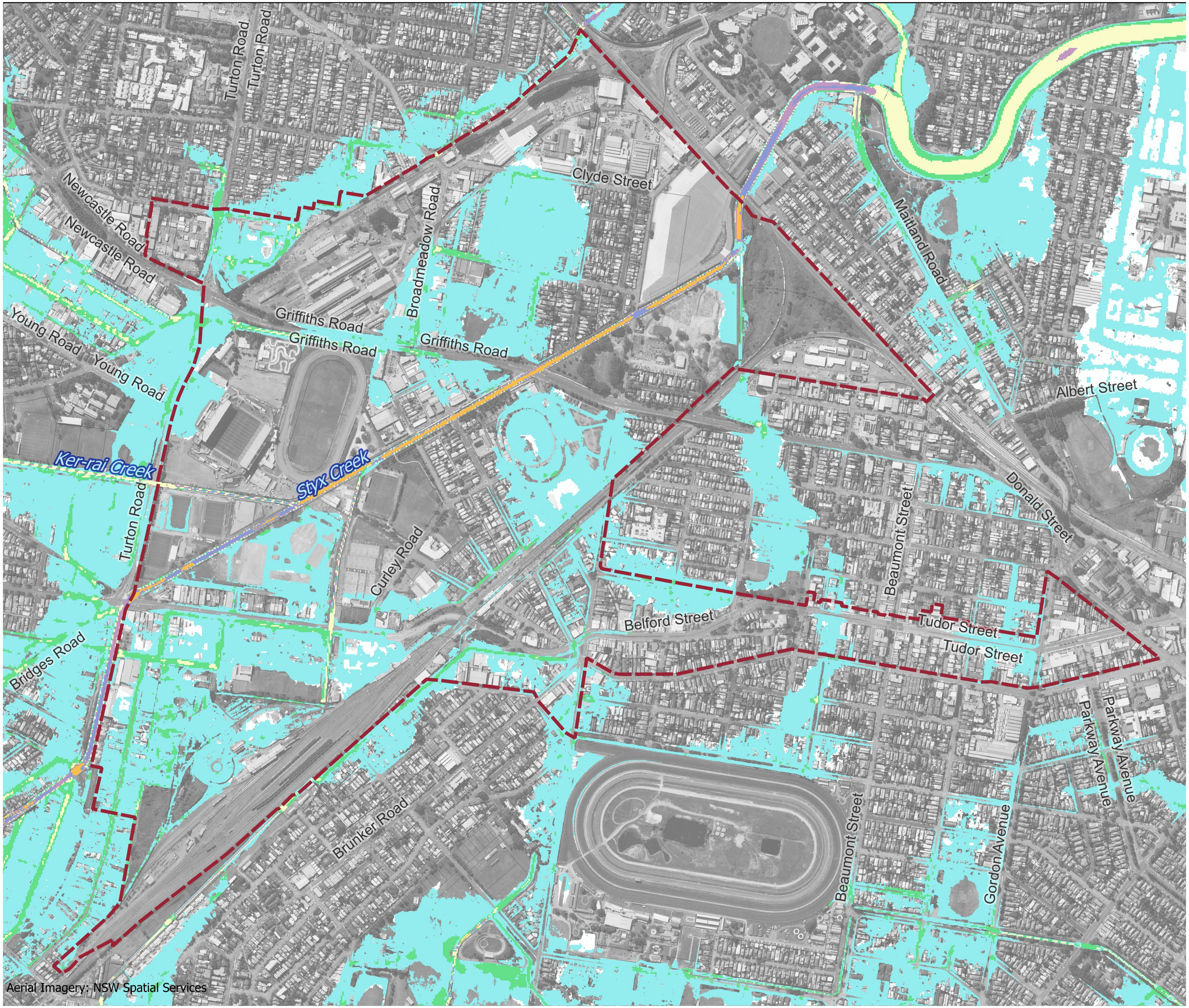
Study Area

Cadastre

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-112

Existing 2% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

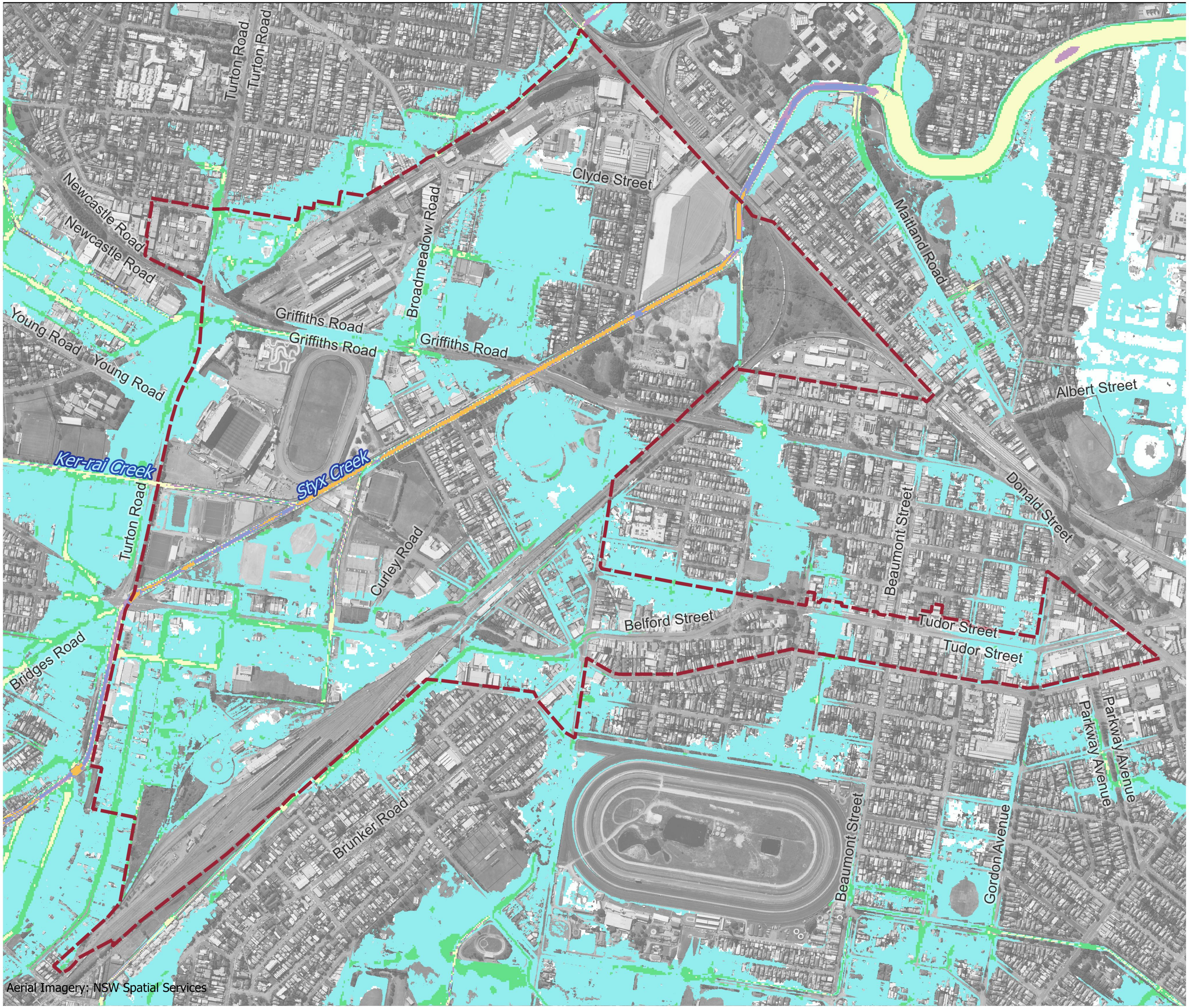
Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-113

Existing 1% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3

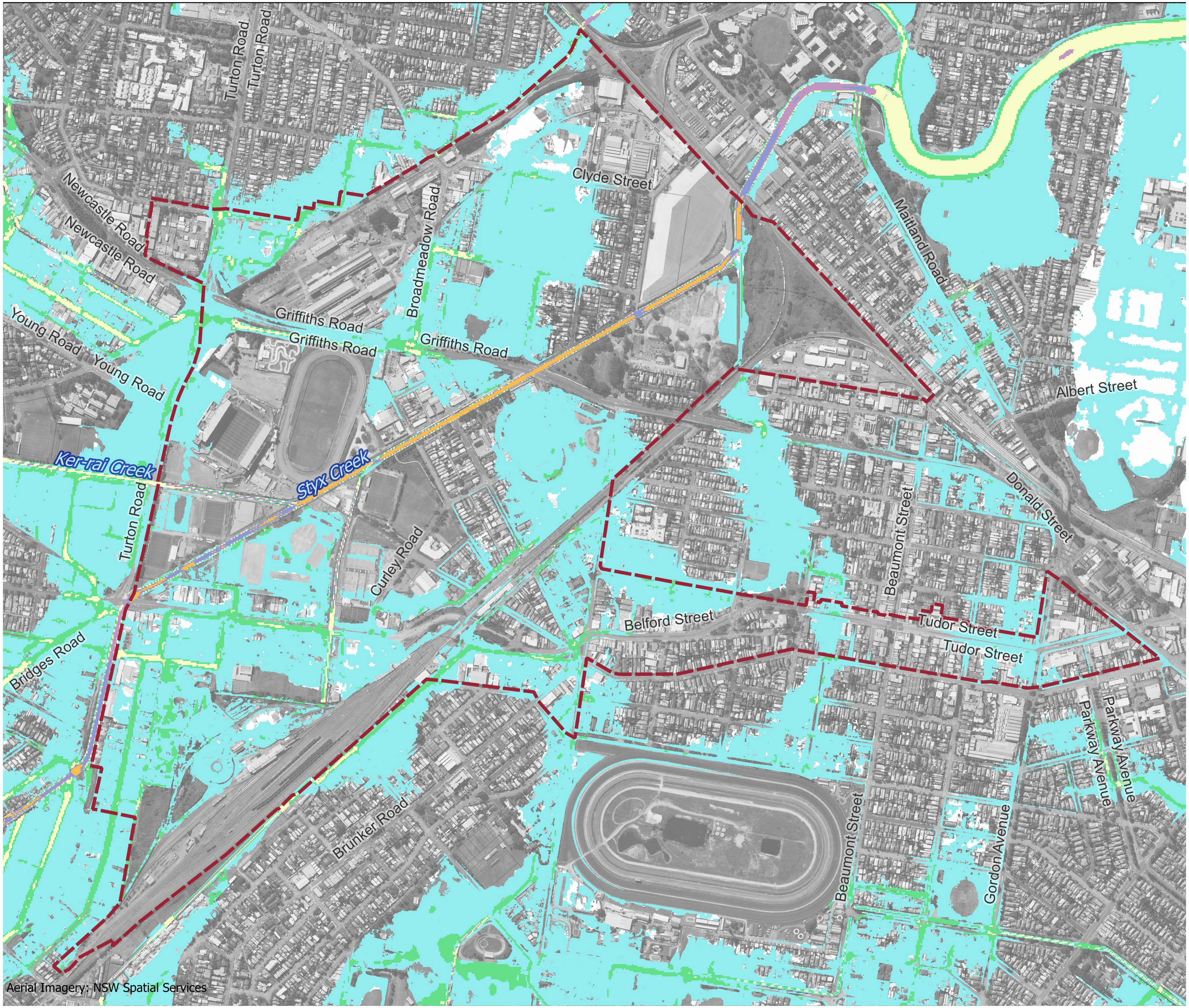
Date : 22 Dec 2023

Revision : 02

Created by : DR

Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-114

**Existing
0.5% AEP Peak Flood
Velocity**

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

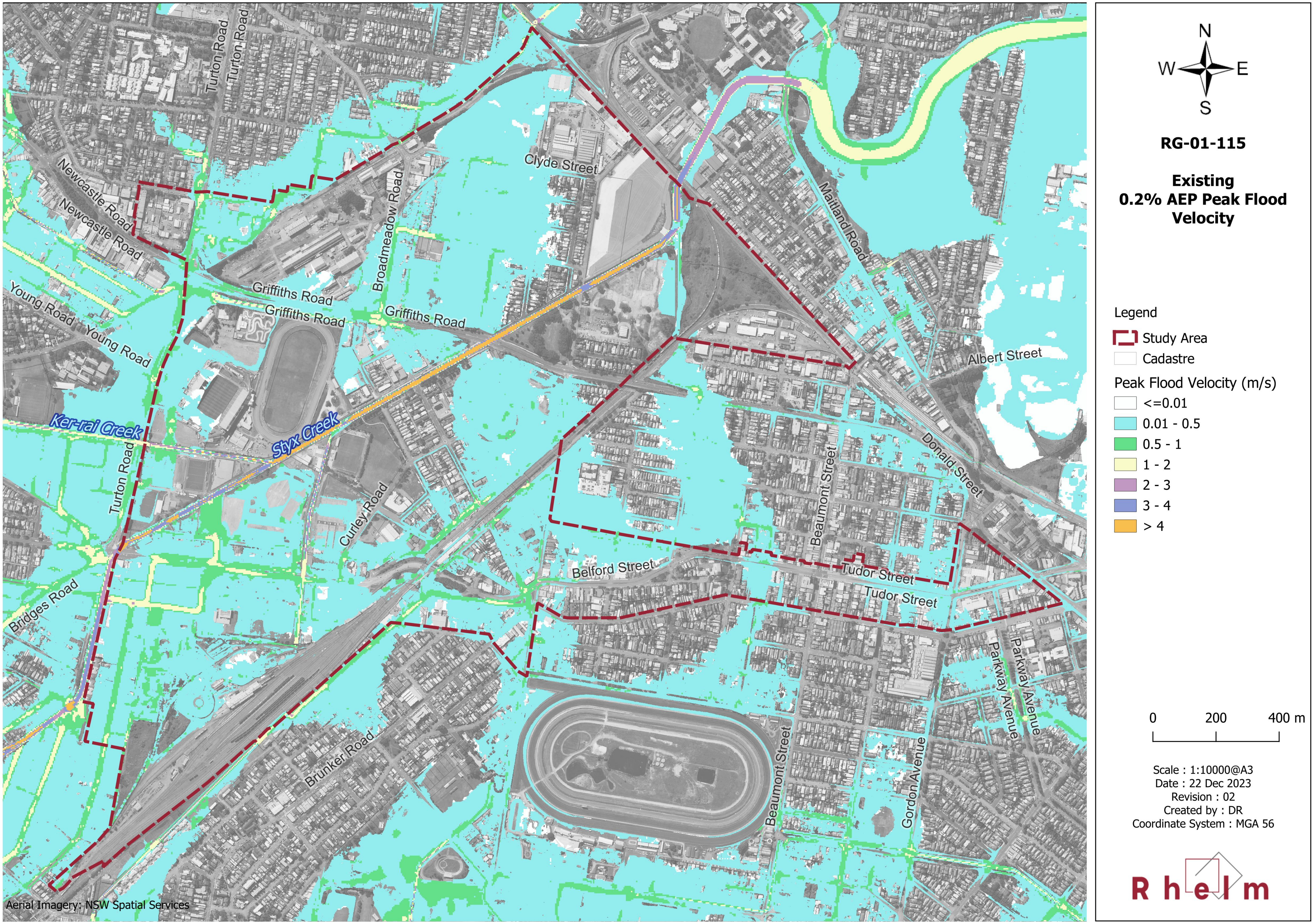
3 - 4

> 4

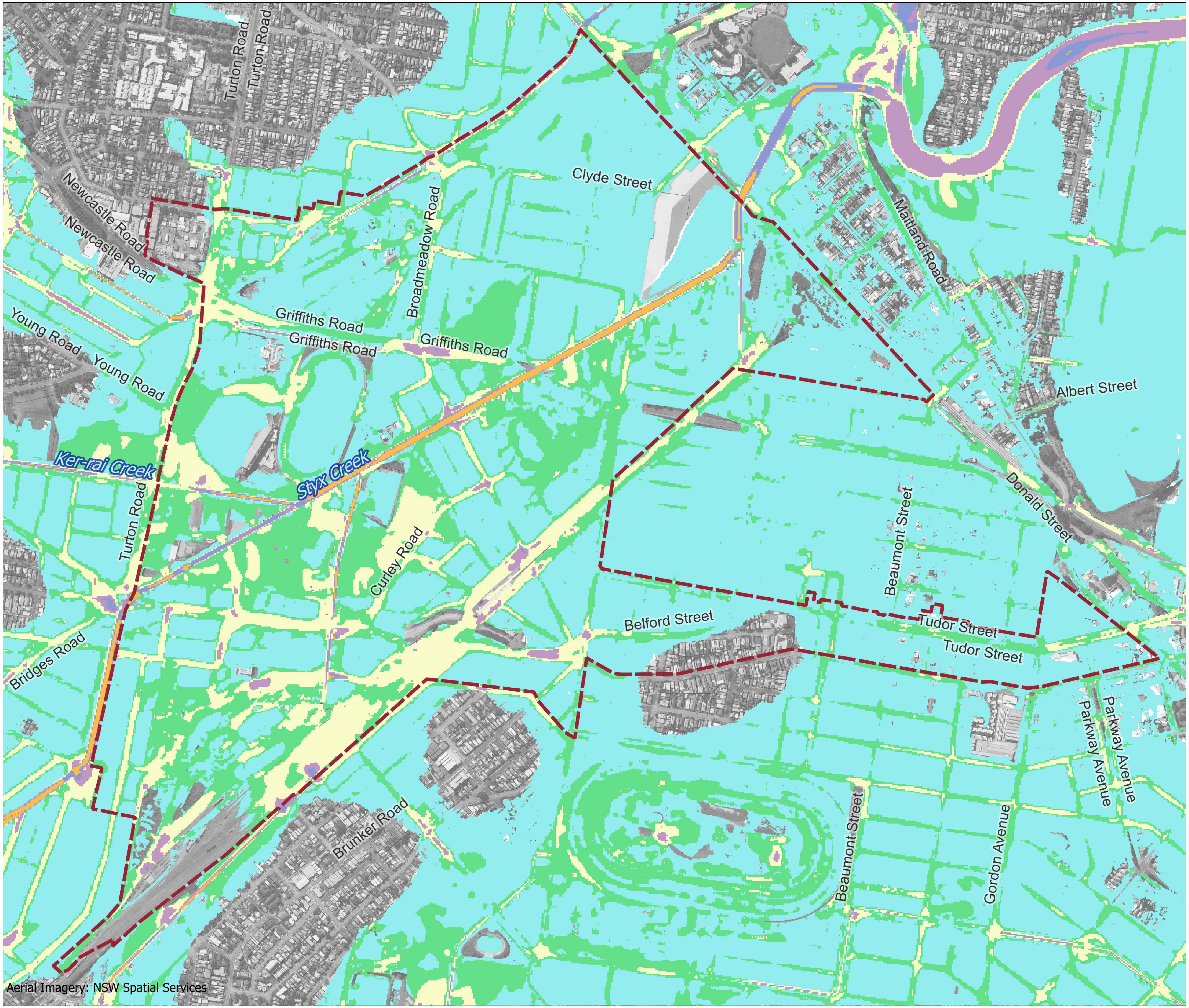
0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



Turton Road
Turton Road
Clyde Street
Maitland Road
Newcastle Road
Newcastle Road
Broadmeadow Road
Griffiths Road
Griffiths Road
Griffiths Road
Young Road
Young Road
Albert Street
Ker-rai Creek
Styx Creek
Turton Road
Donald Street
Beaumont Street
Curley Road
Belford Street
Tudor Street
Tudor Street
Bridges Road
Parkway Avenue
Parkway Avenue
Brunker Road
Beaumont Street
Gordon Avenue
Aerial Imagery: NSW Spatial Services
N
W
E
S
RG-01-115
Existing
0.2% AEP Peak Flood
Velocity
Legend
Study Area
Cadastre
Peak Flood Velocity (m/s)
<=0.01
0.01 - 0.5
0.5 - 1
1 - 2
2 - 3
3 - 4
> 4
0
200
400 m
Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56
Rhelm



N
W E
S

RG-01-116

Existing
PMF Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

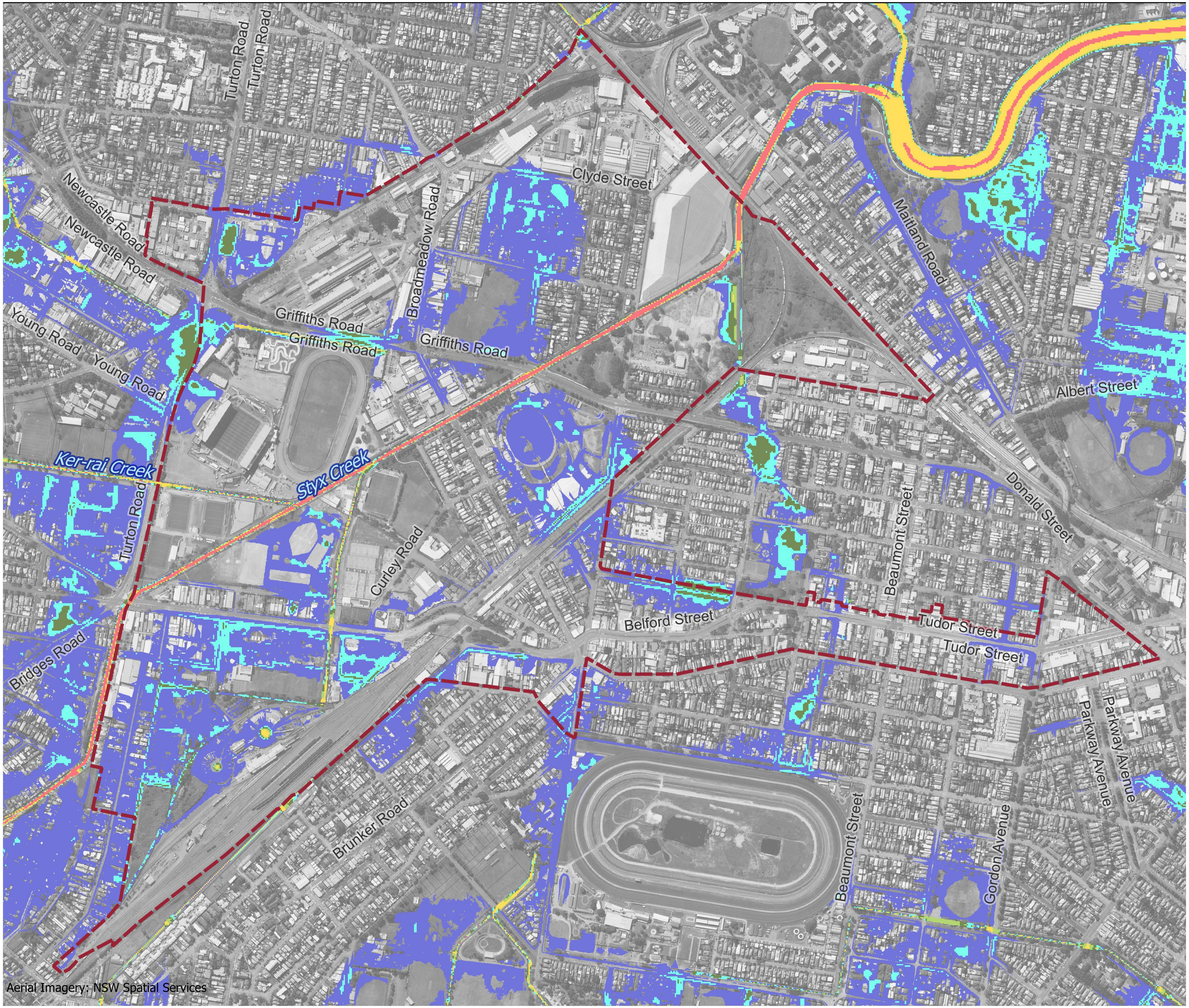
3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-120

Existing
10% AEP Peak Flood
Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

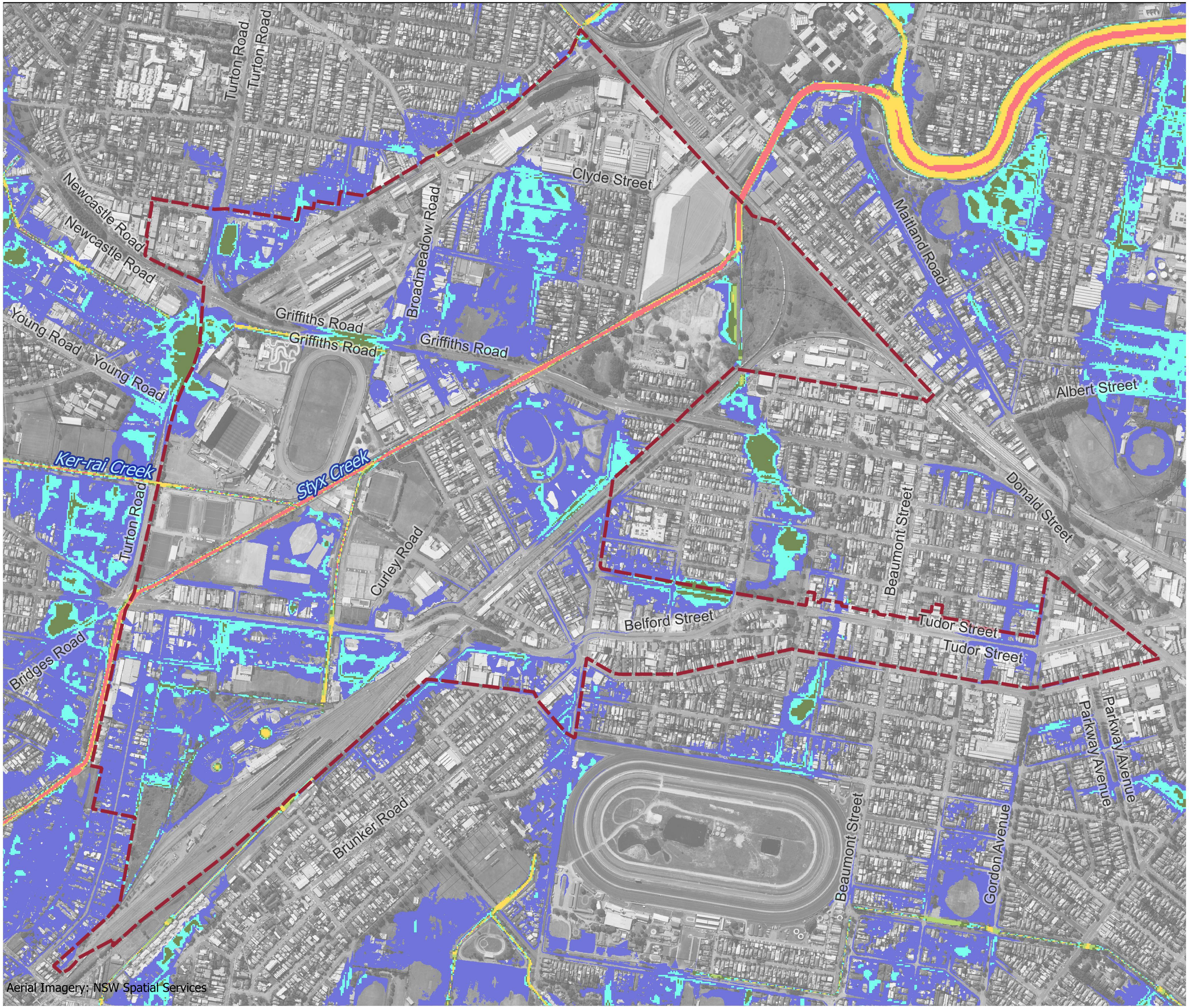
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-121

Existing 5% AEP Peak Flood Hazard

Legend

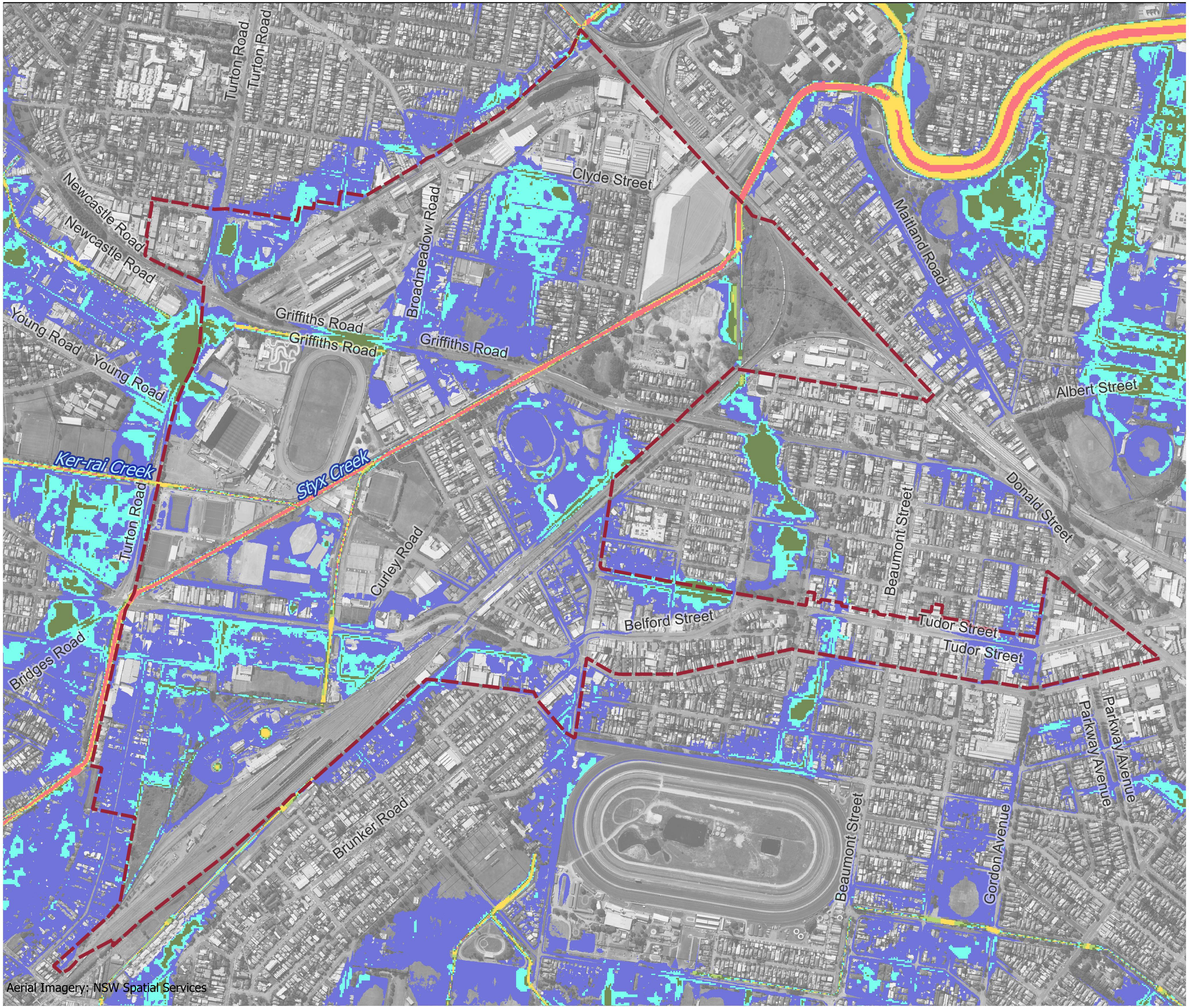
Study Area

Cadastre

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-122

Existing 2% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

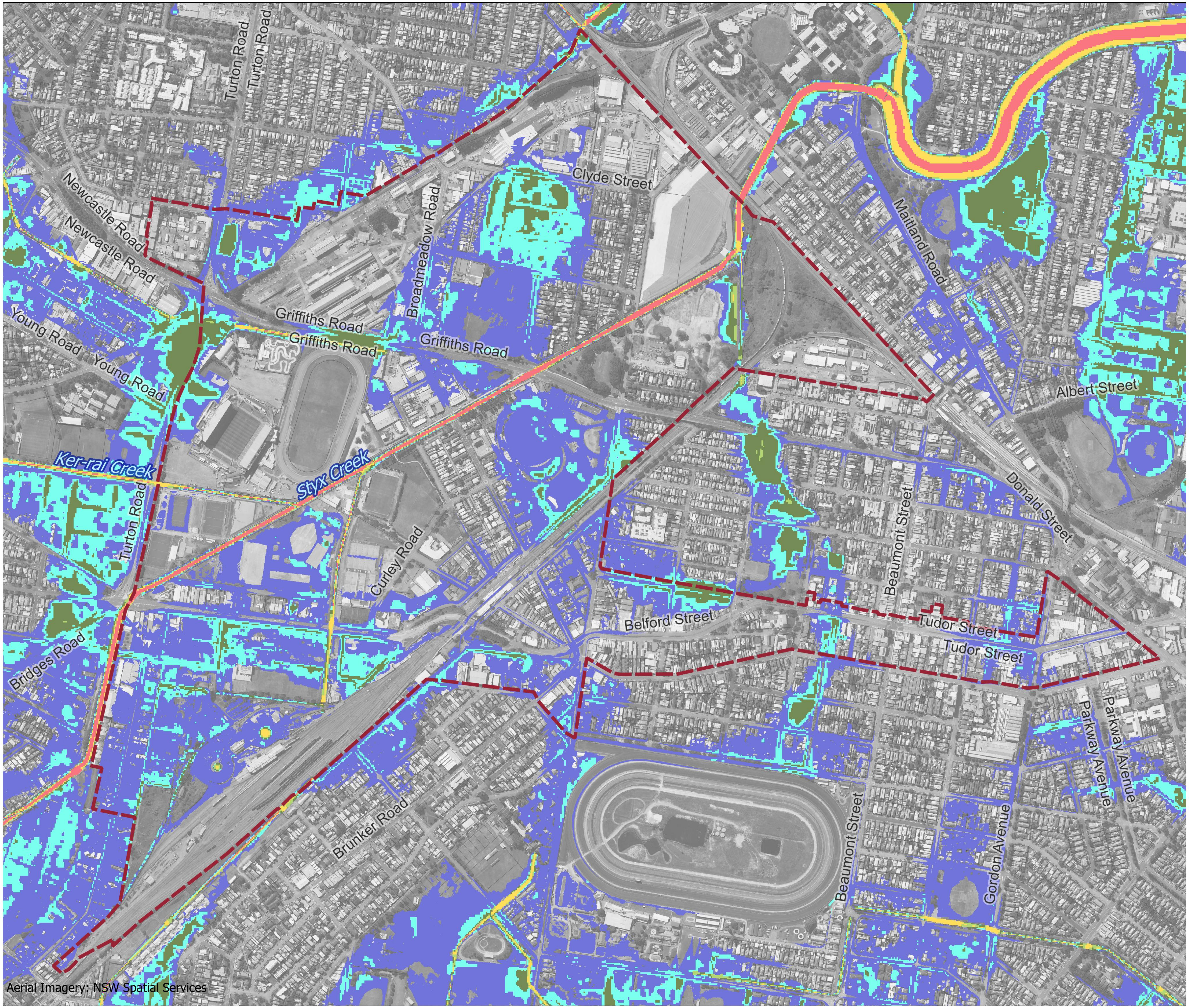
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-01-123

Existing
1% AEP Peak Flood Hazard

Legend

- Study Area
- Cadastre

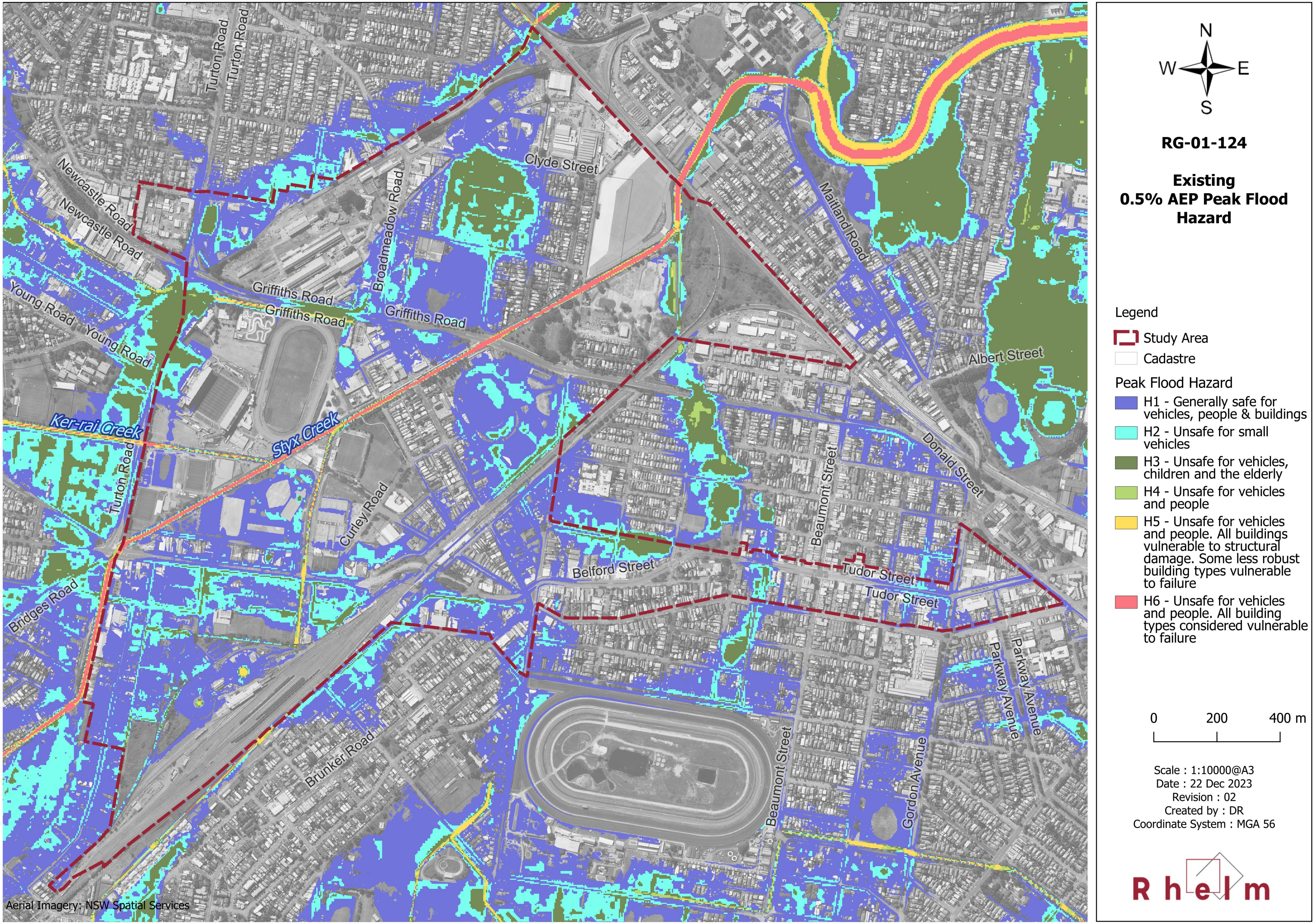
Peak Flood Hazard

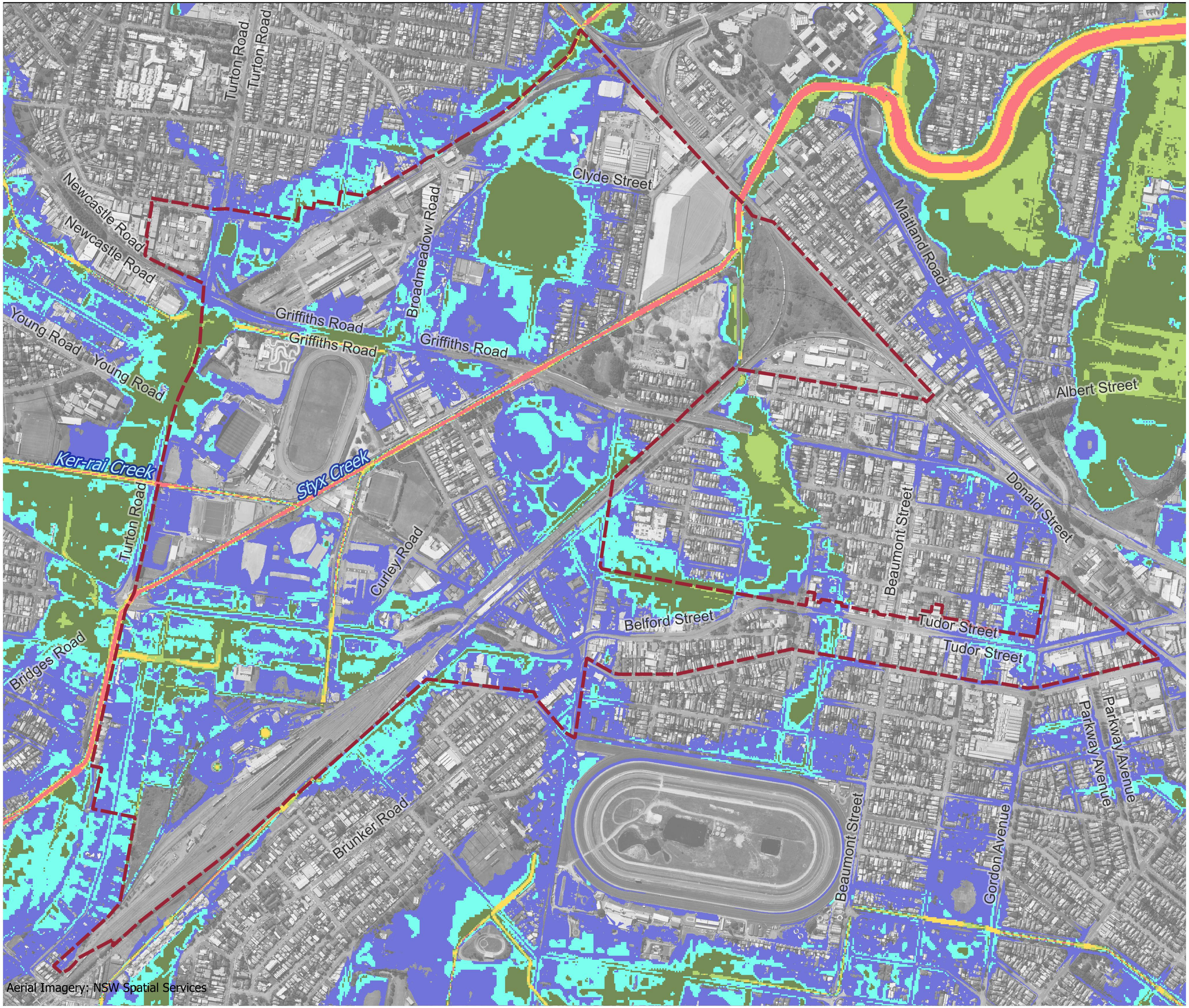
- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm


Turton Road
Turton Road
Clyde Street
Newcastle Road
Newcastle Road
Broadmeadow Road
Maitland Road
Griffiths Road
Griffiths Road
Griffiths Road
Young Road
Young Road
Albert Street
Ker-rai Creek
Styx Creek
Turton Road
Donald Street
Beaumont Street
Curley Road
Belford Street
Tudor Street
Tudor Street
Bridges Road
Parkway Avenue
Parkway Avenue
Brunker Road
Beaumont Street
Gordon Avenue
Aerial Imagery: NSW Spatial Services
N
W
E
S
RG-01-124
Existing
0.5% AEP Peak Flood
Hazard
Legend
Study Area
Cadastre
Peak Flood Hazard
H1 - Generally safe for vehicles, people & buildings
H2 - Unsafe for small vehicles
H3 - Unsafe for vehicles, children and the elderly
H4 - Unsafe for vehicles and people
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure
0
200
400 m
Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56
Rhelm



N
W E
S

RG-01-125

Existing 0.2% AEP Peak Flood Hazard

Legend

- Study Area
- Cadastre

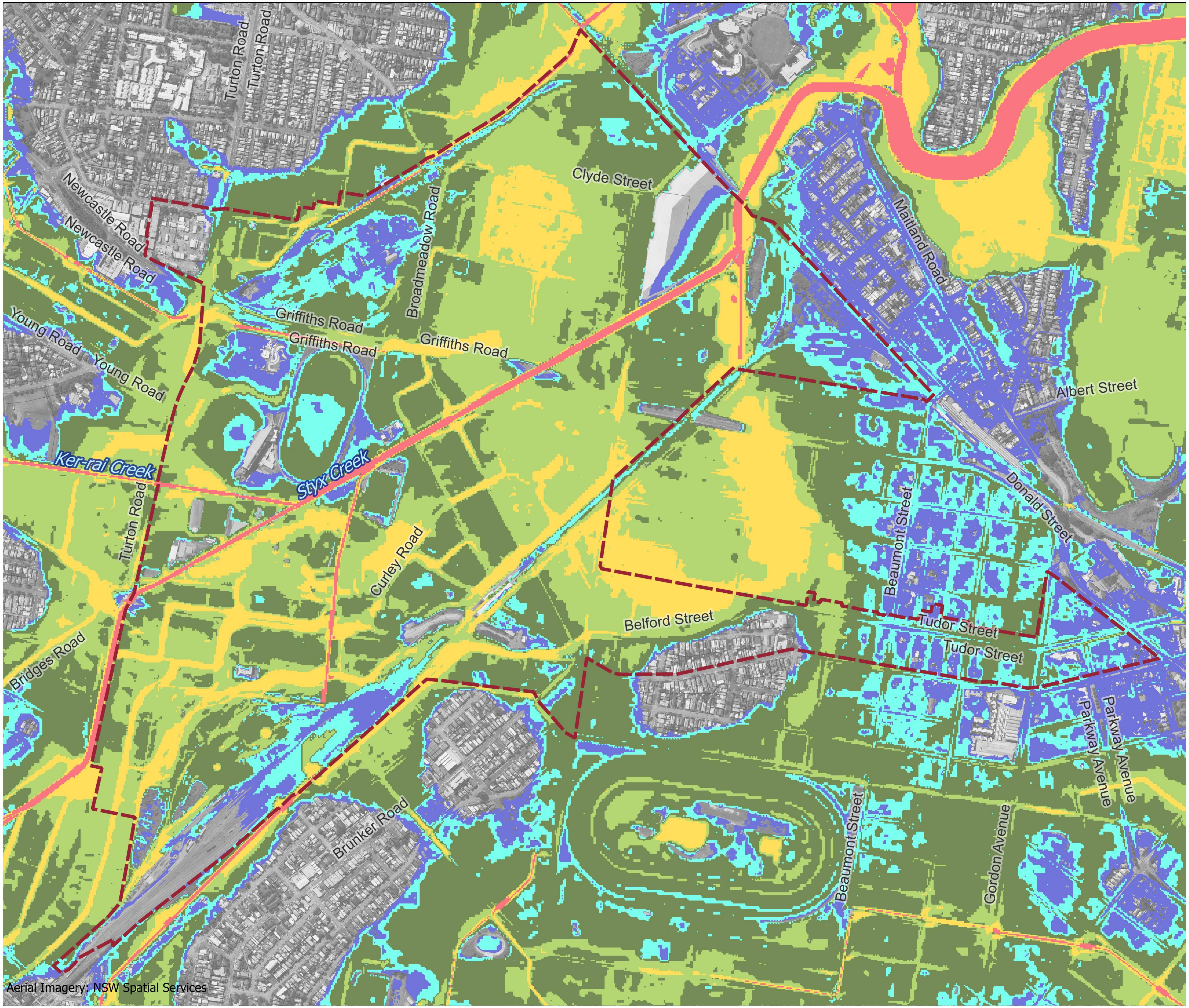
Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-126

Existing
PMF Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm

N
W E
S

RG-01-131

Existing Flood Emergency Response Classifications

Legend

Study Area
DFE Flood Extent
PMF Flood Extent

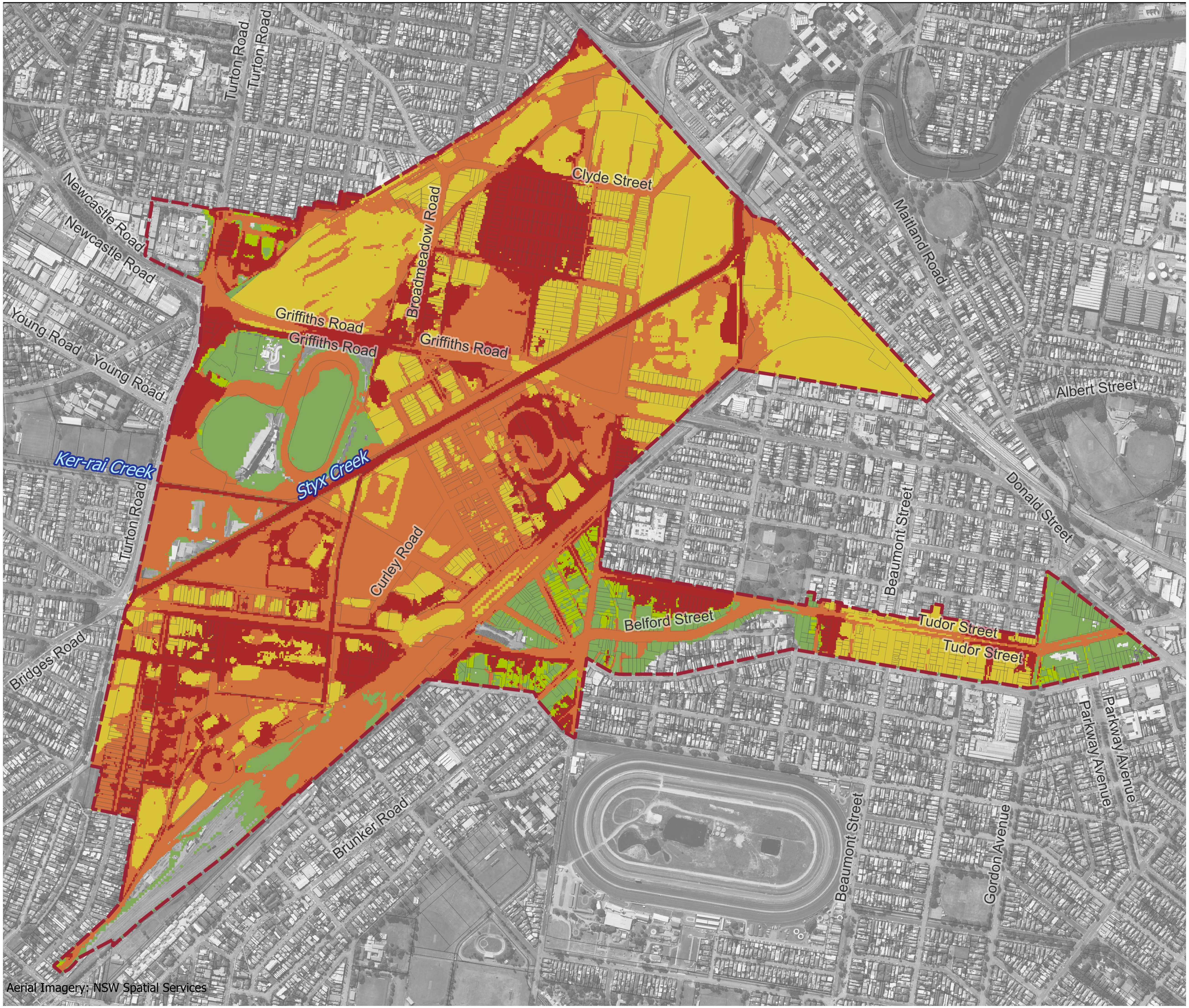
PMF FERC

Flooded, Isolated, Submerged
Flooded, Exit Route Overland
Not Floded, Indirect Consequences

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-141

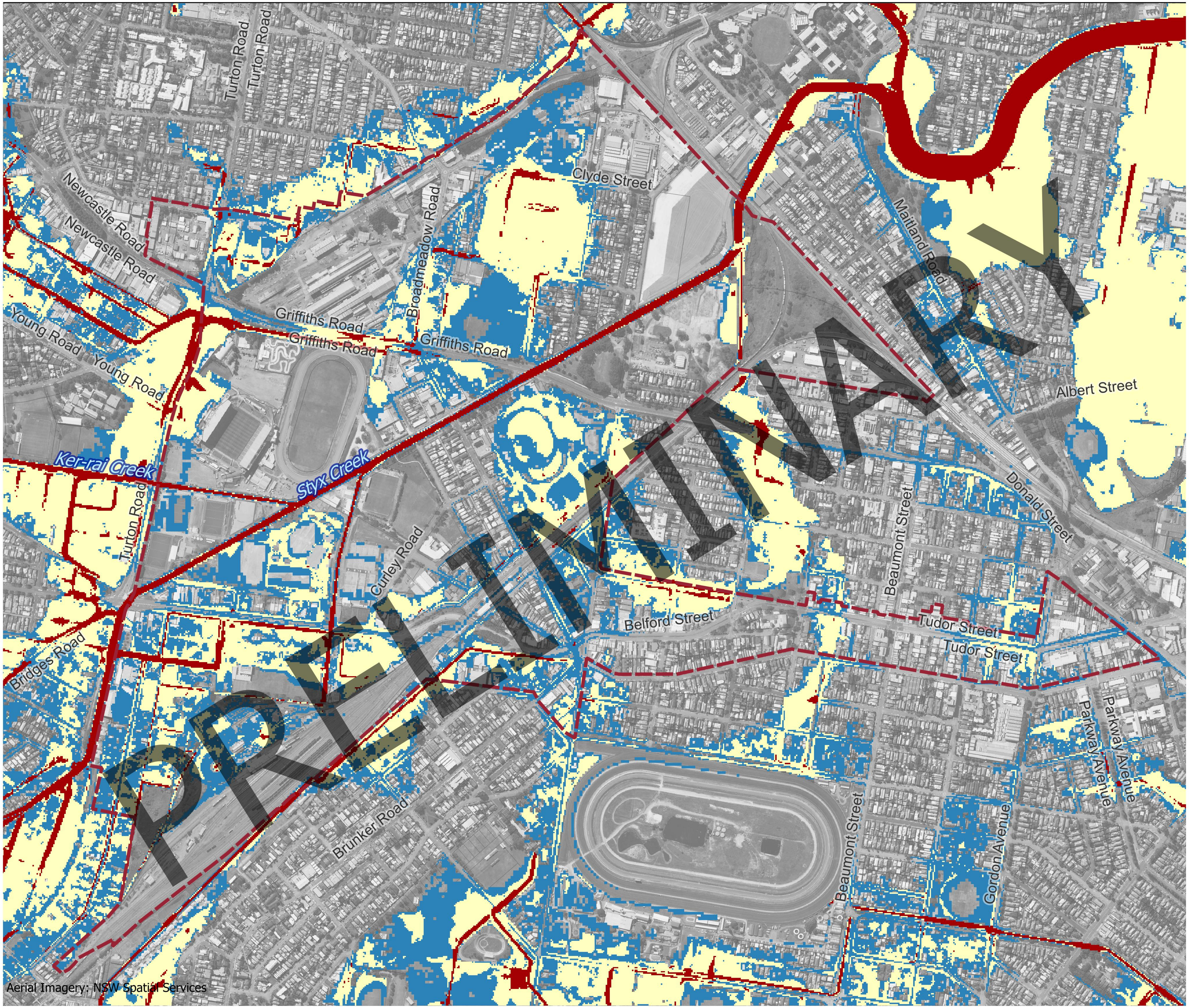
Existing Flood Planning Constraint Categories

Legend
- Study Area
- Cadastre
- FPCC_01a
- FPCC_2a
- FPCC_2c
- FPCC_03
- FPCC_04

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-150

Existing 1% AEP in 2050 Flood Function

Legend

Study Area

Cadastre

Flood Function

Floodway

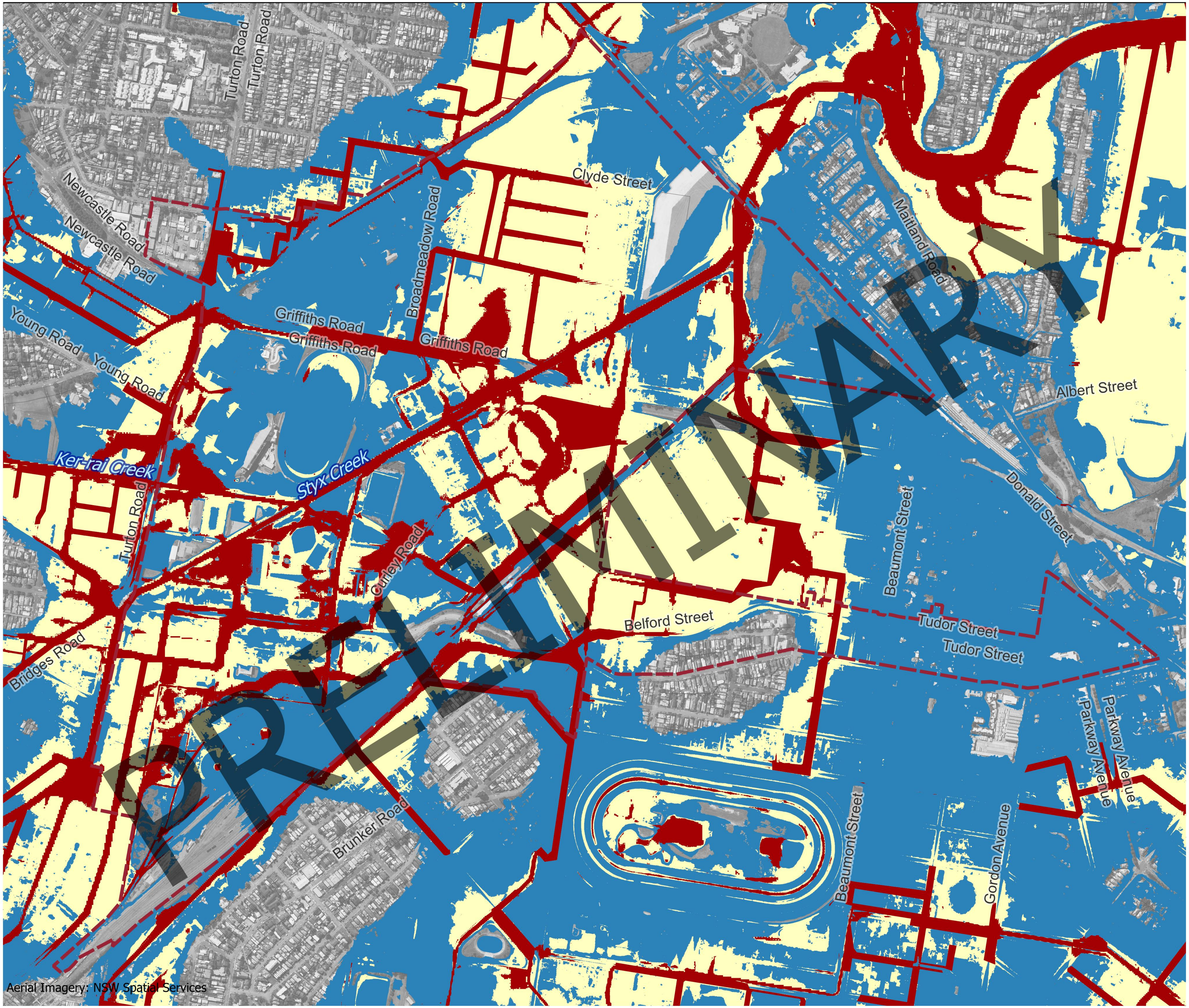
Flood Storage

Flood Fringe

0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm



N
W E
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RG-01-151

Existing PMF Flood Function

Legend

Study Area

Cadastre

Flood Function

Floodway

Flood Storage

Flood Fringe

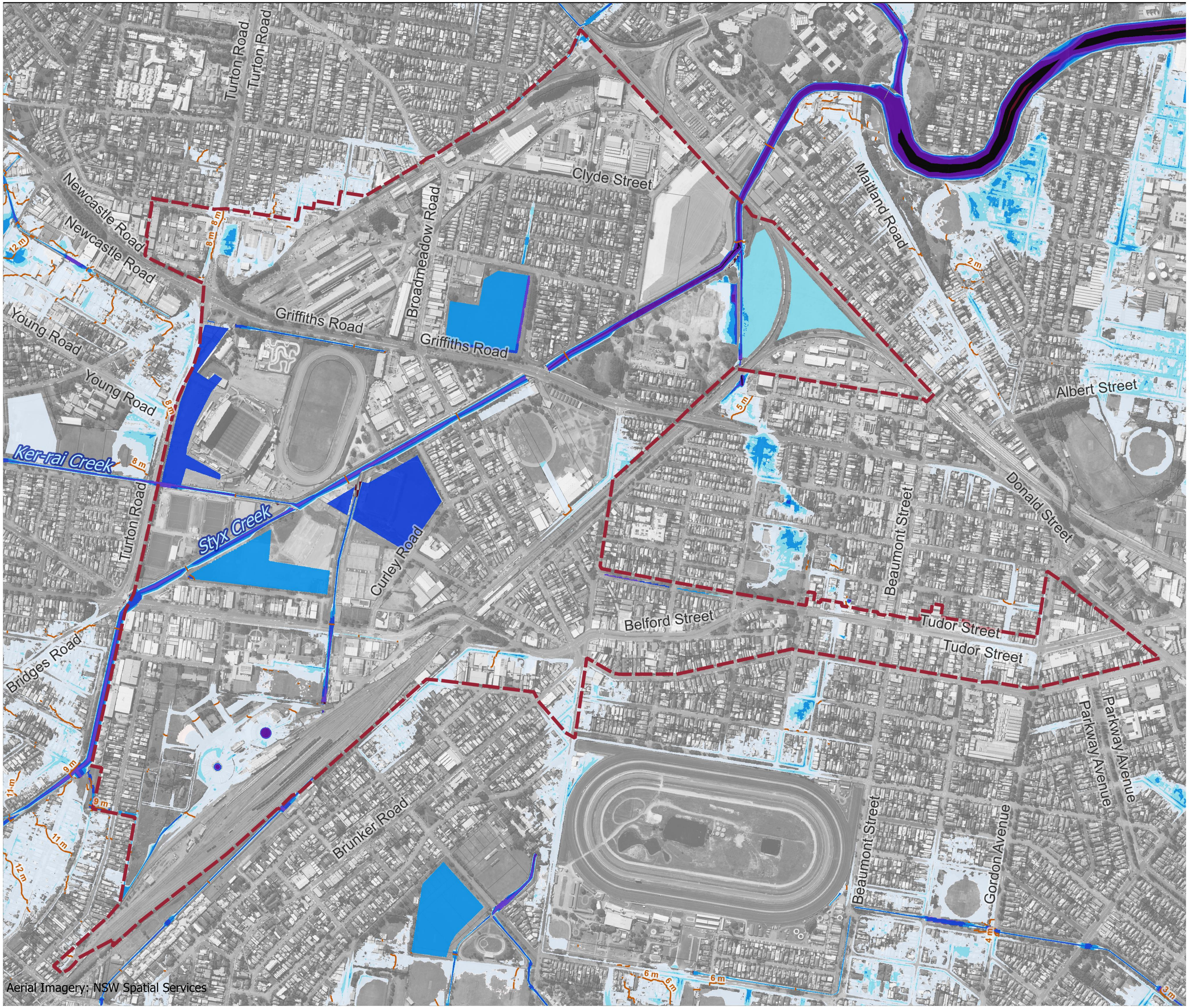
0 200 400 m

Scale : 1:10000@A3
Date : 22 Dec 2023
Revision : 02
Created by : DR
Coordinate System : MGA 56

Rhelm

Appendix B

Post-Development Scenario Flood Mapping



N
W E
S

RG-02-100

Post Development 10% AEP Peak Flood Depth and Elevation

Legend

Study Area
Cadastre
1m Water Level Contours

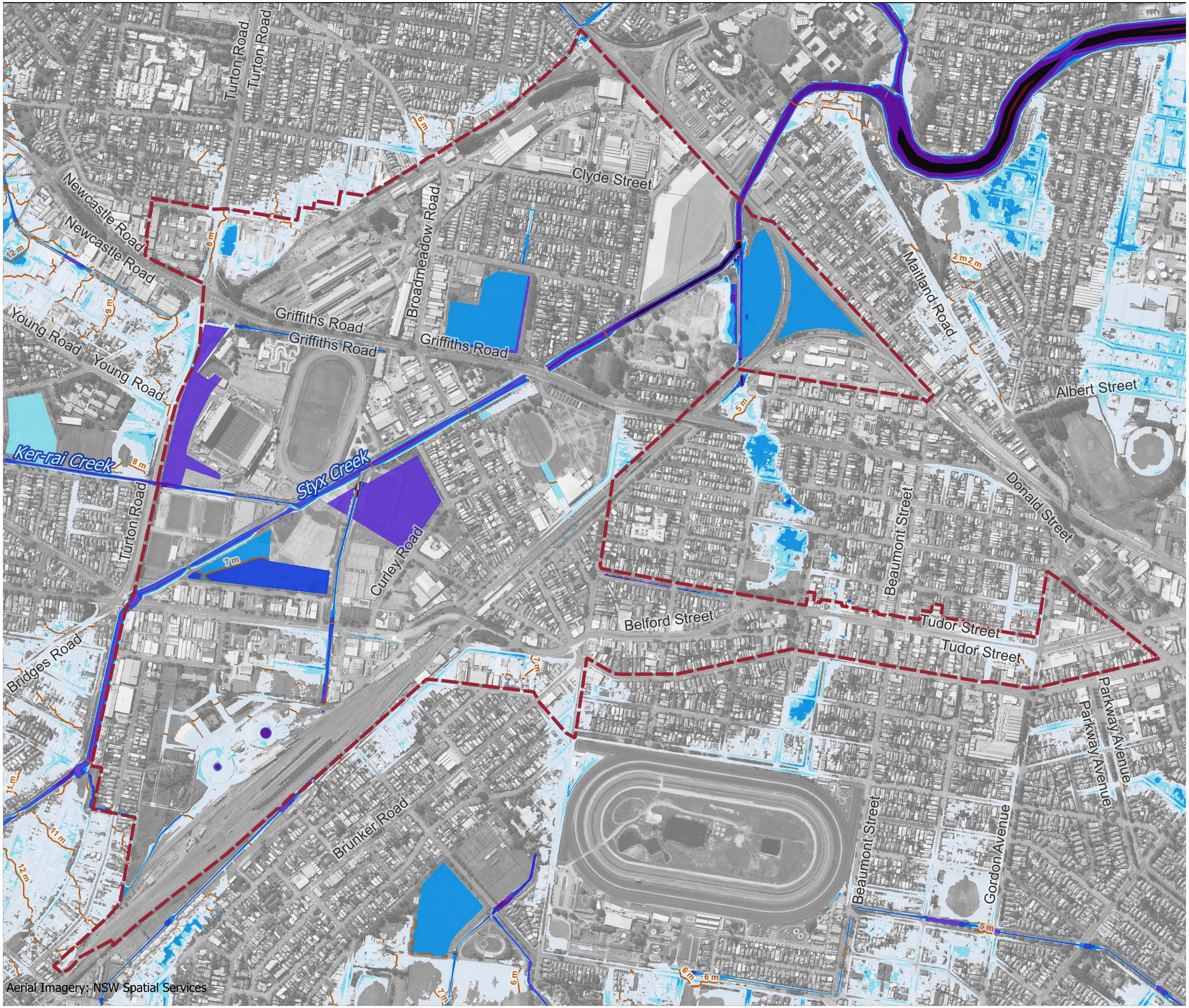
Peak Flood Depth (m)

<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-101

Post Development 5% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

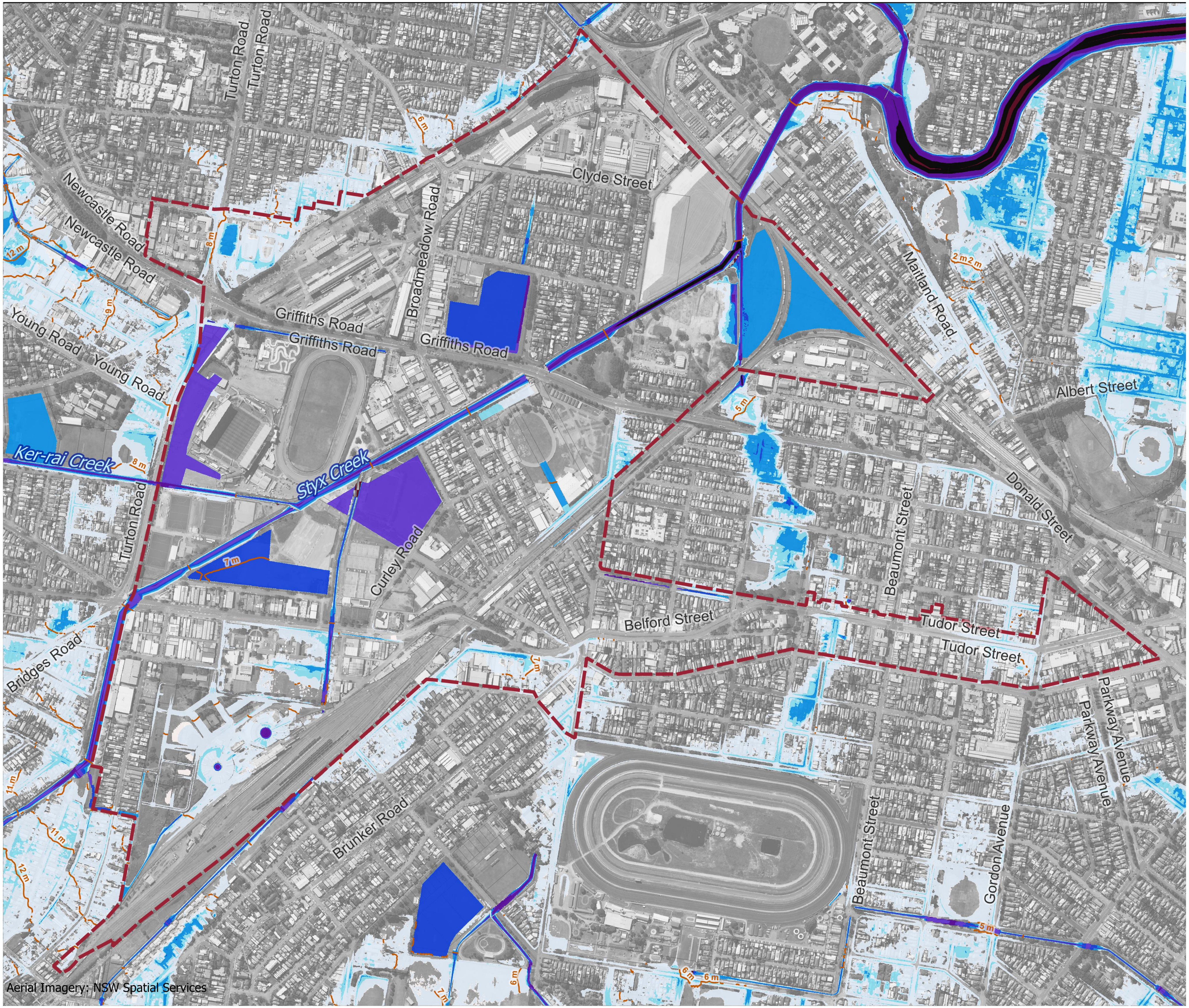
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
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RG-02-102

Post Development 2% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

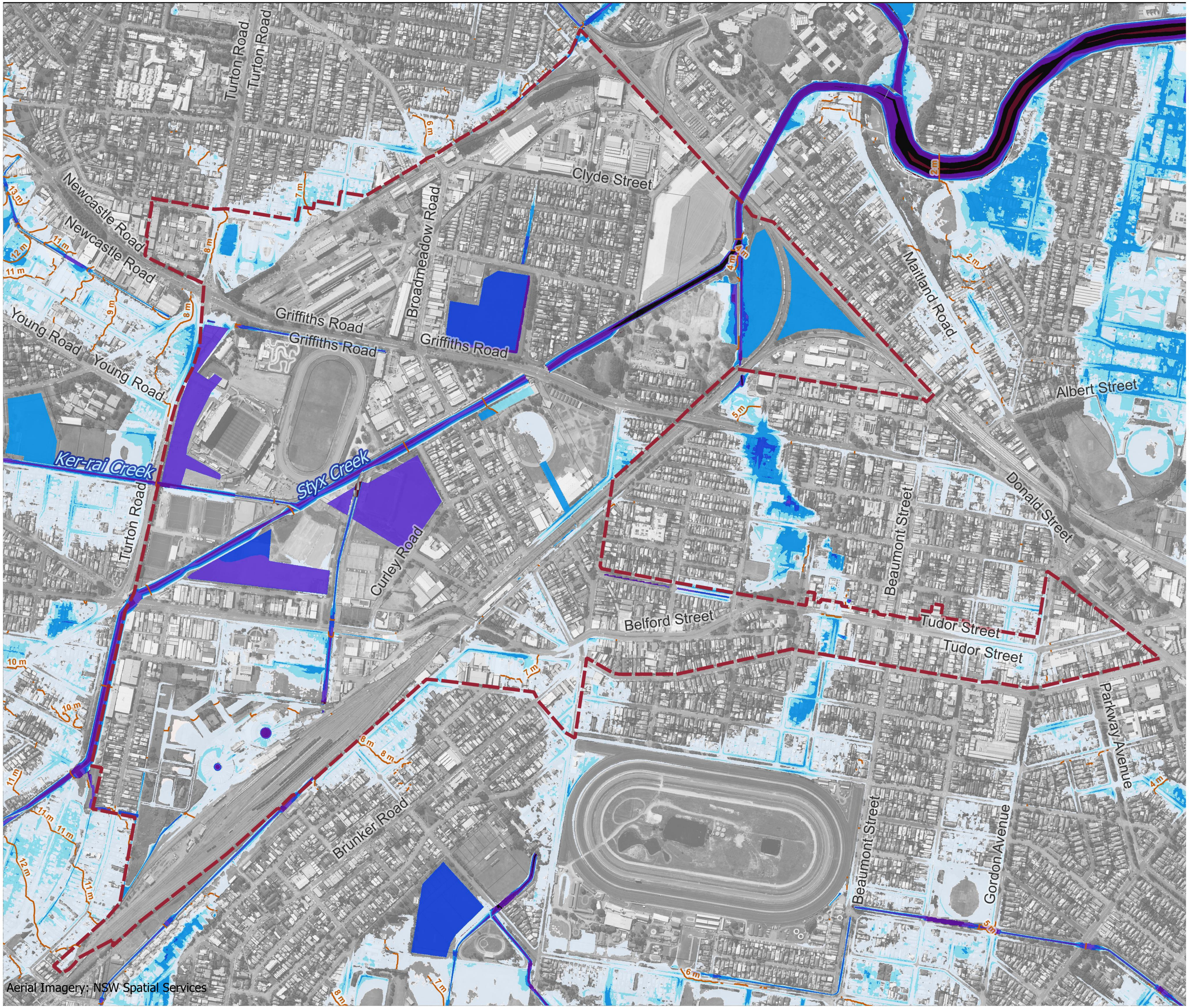
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-103

Post Development 1% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

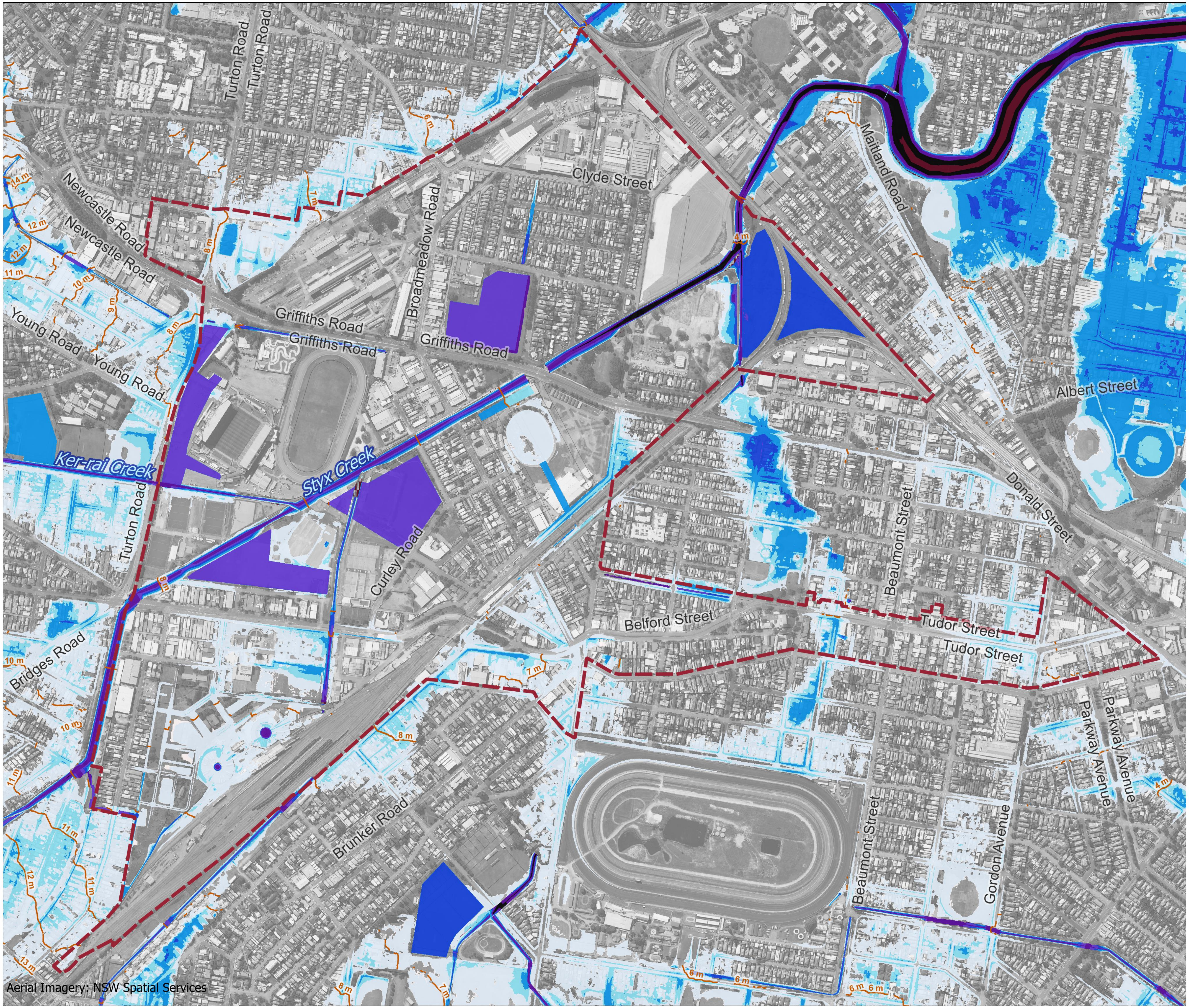
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-104

Post Development 0.5% AEP Peak Flood Depth and Elevation

Legend

Study Area
Cadastre
1m Water Level Contours

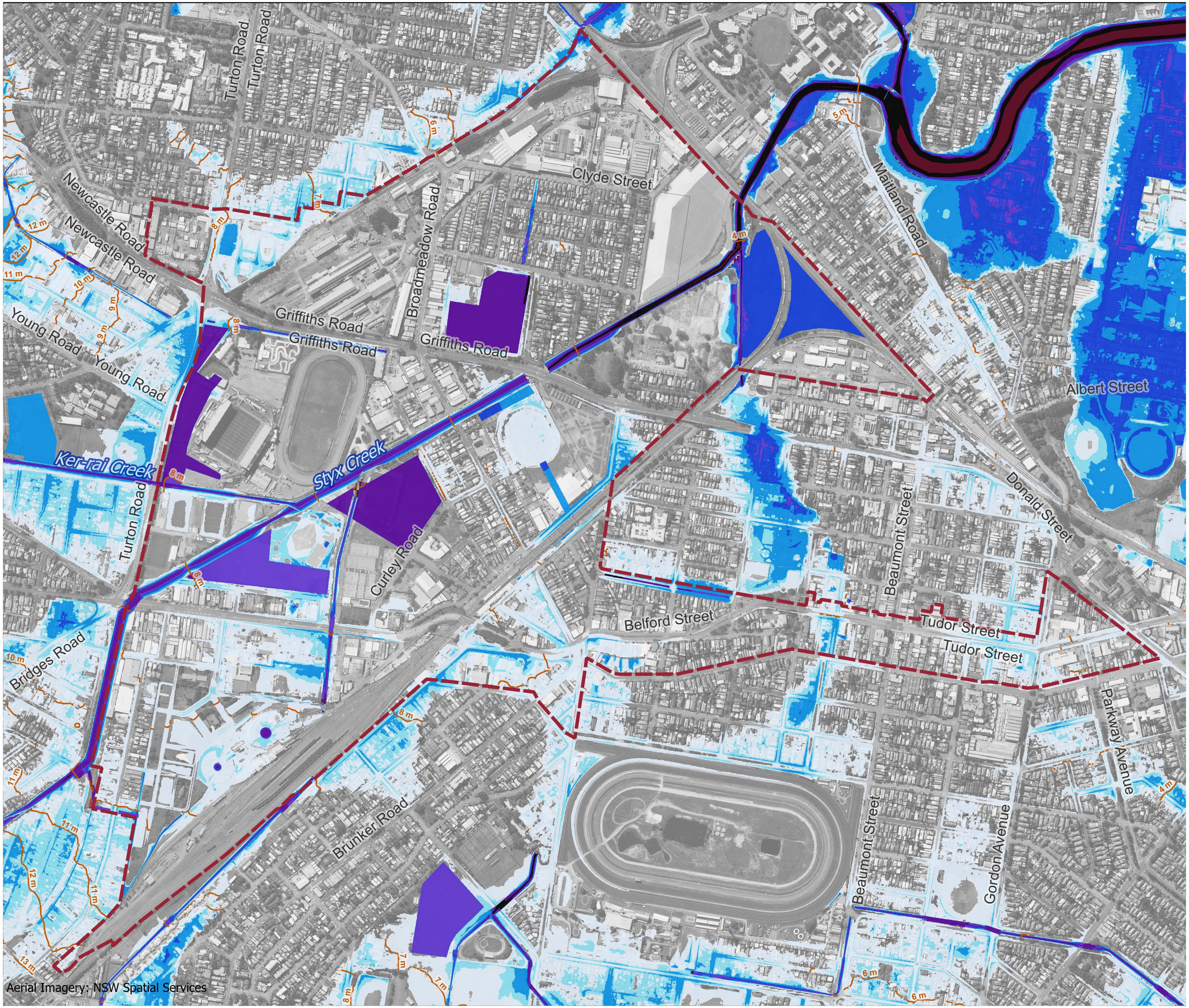
Peak Flood Depth (m)

<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-105

Post Development 0.2% AEP Peak Flood Depth and Elevation

Legend

Study Area
Cadastre
1m Water Level Contours

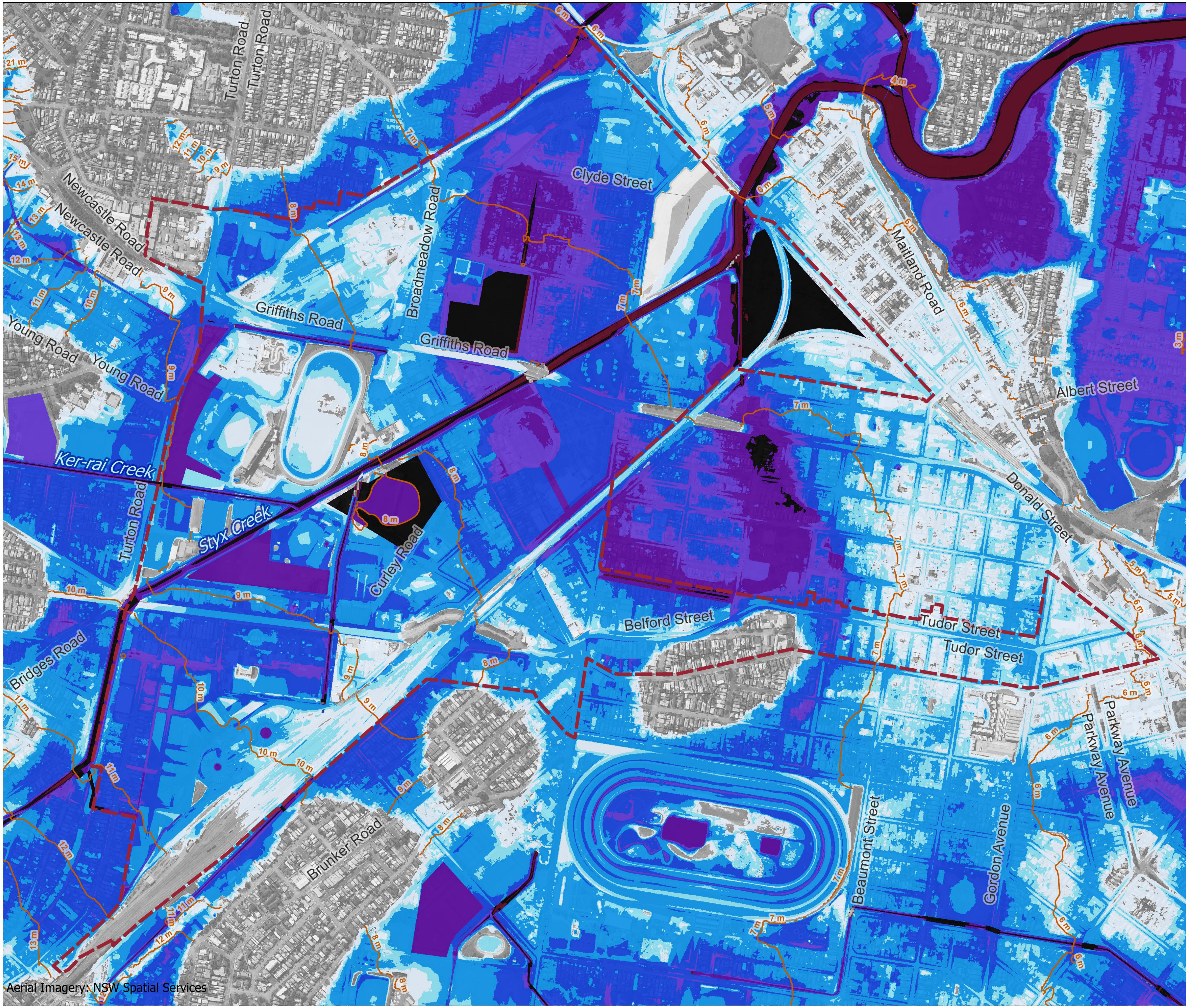
Peak Flood Depth (m)

<= 0.01
0.01 - 0.3
0.3 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-106

Post Development
PMF Peak Flood Depth and Elevation

Legend

- Study Area
- Cadastre
- 1m Water Level Contours

Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm

N W E S

RG-02-110

Post Development 10% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

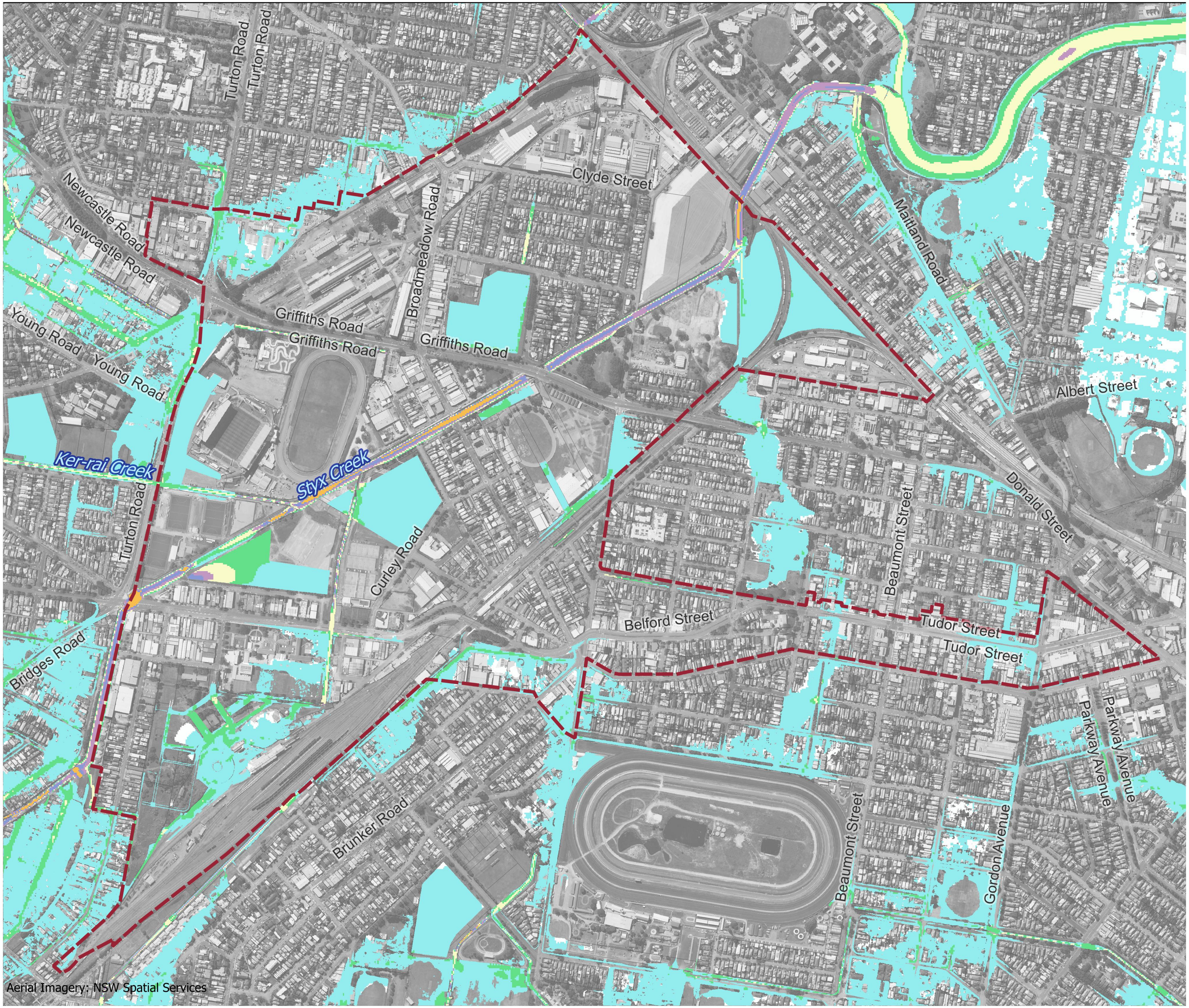
Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-111

Post Development 5% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

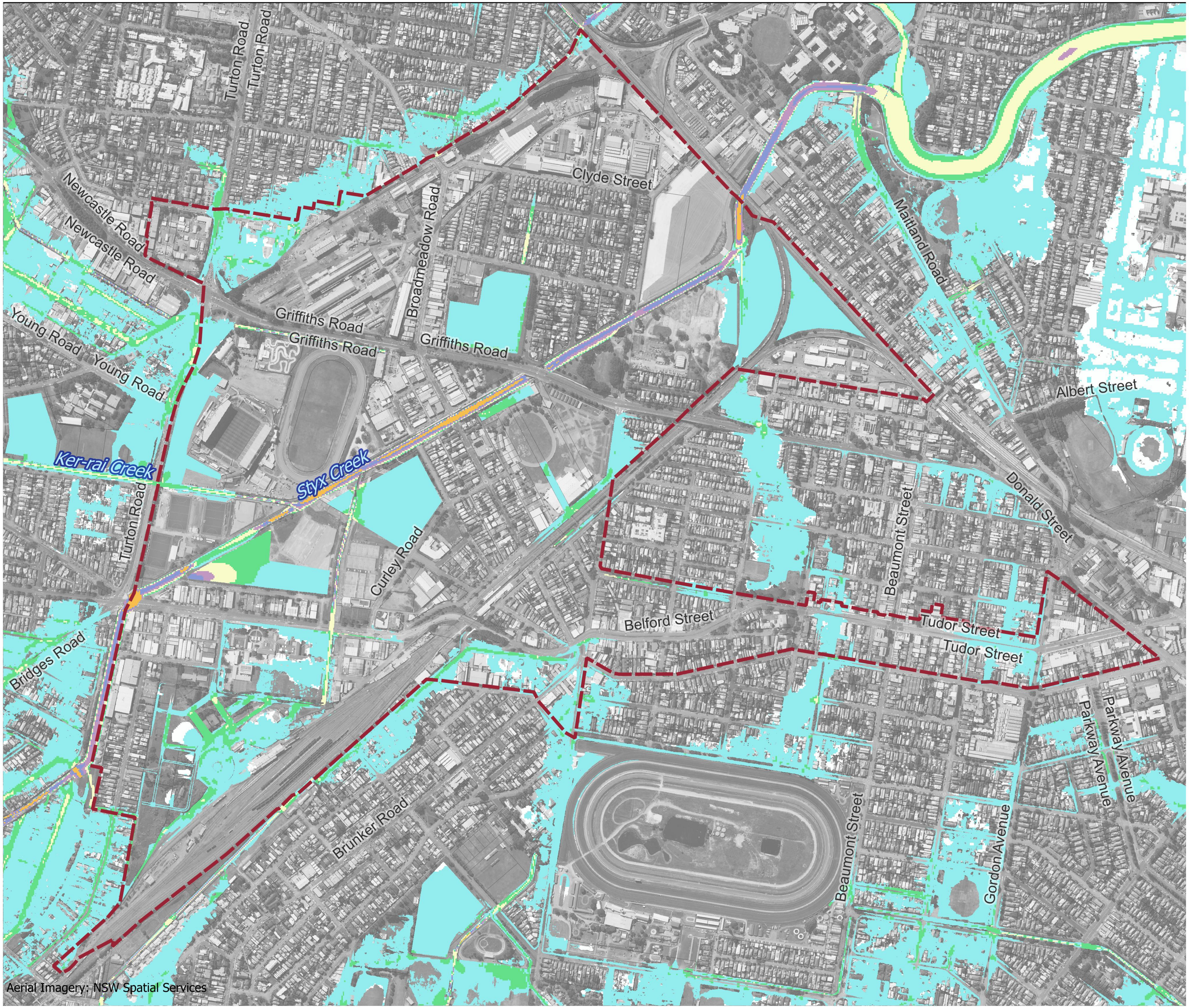
Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-112

Post Development 2% AEP Peak Flood Velocity

Legend

- Study Area
- Cadastre

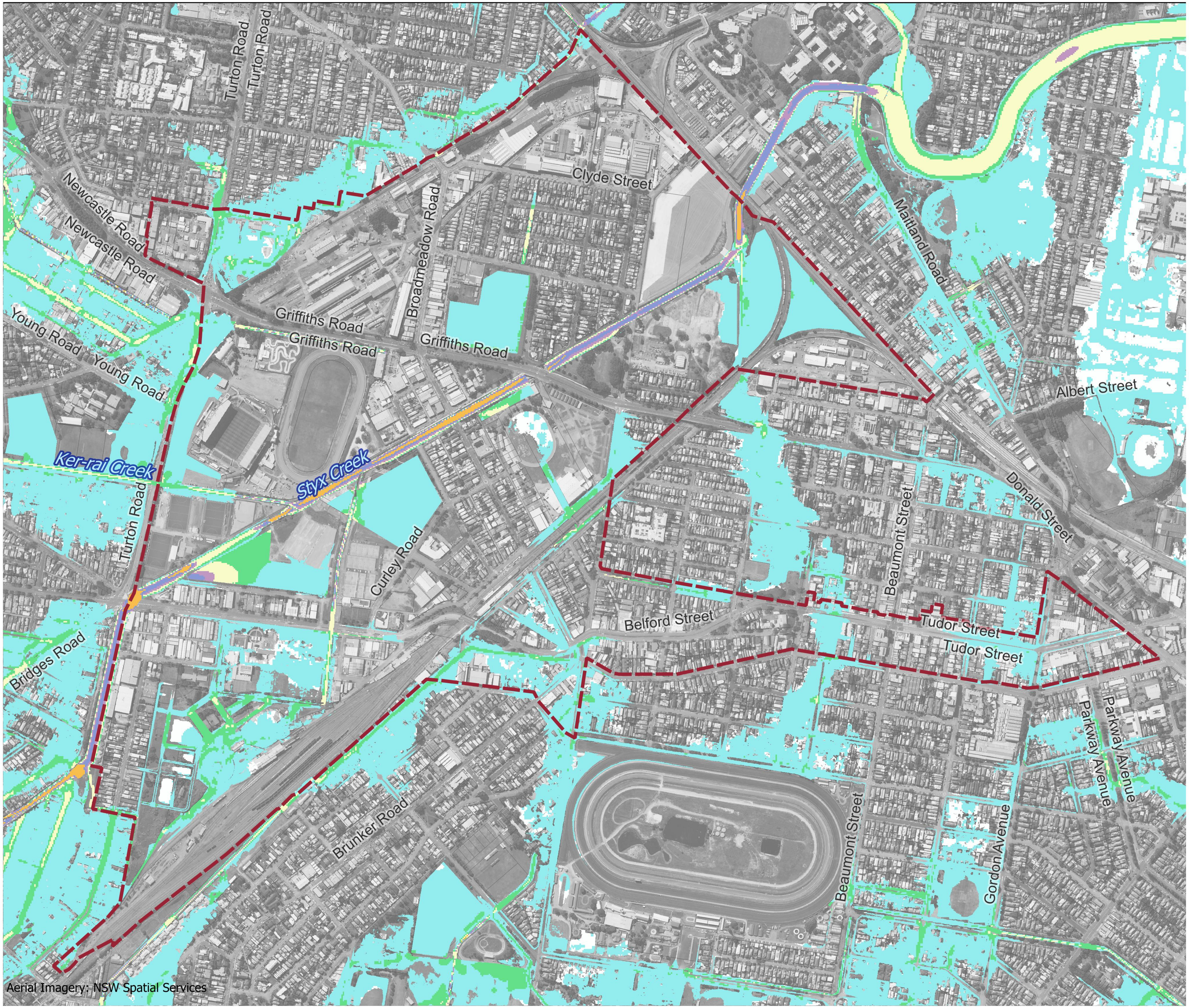
Peak Flood Velocity (m/s)

- <=0.01
- 0.01 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-113

Post Development 1% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

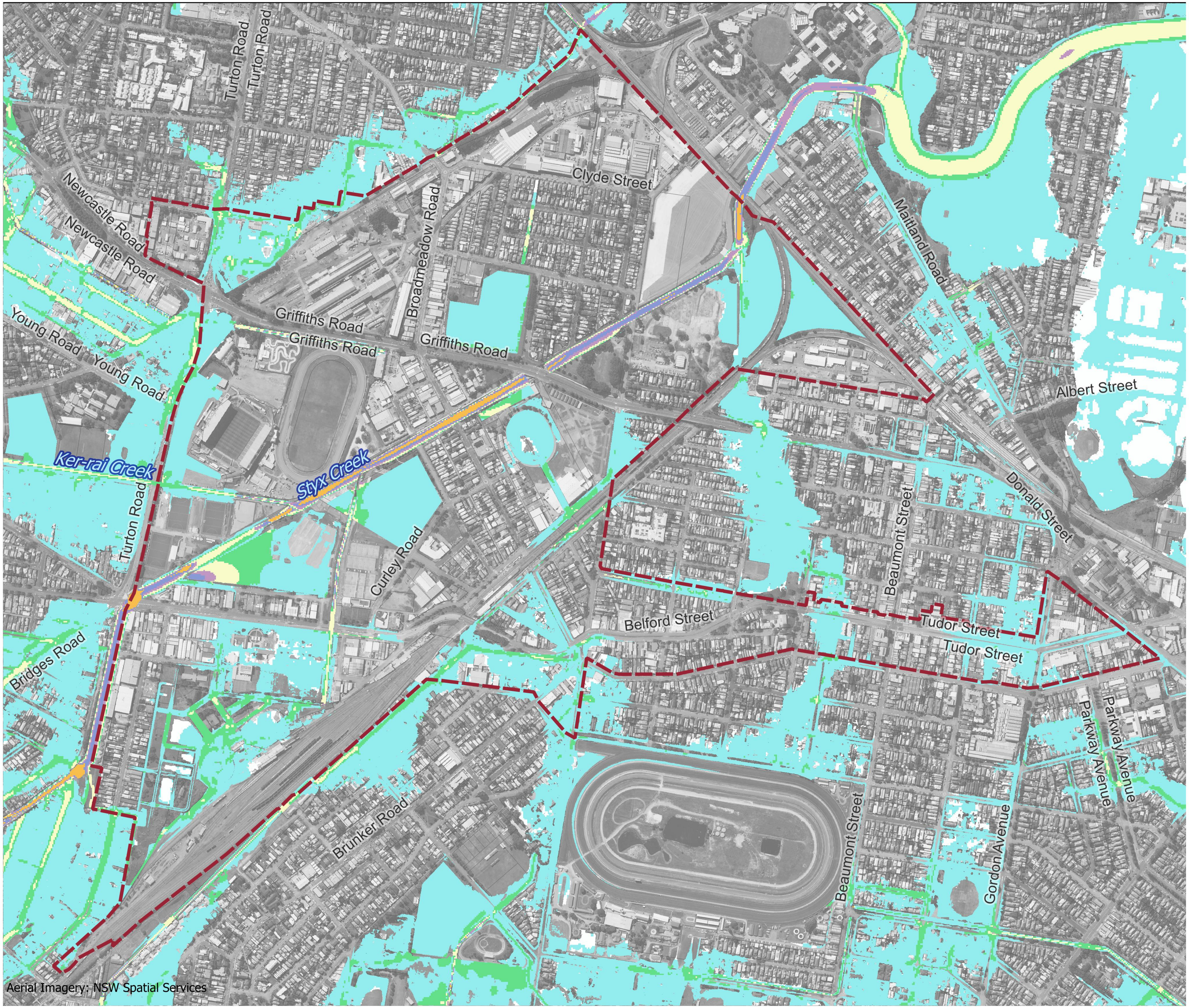
3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-114

Post Development 0.5% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

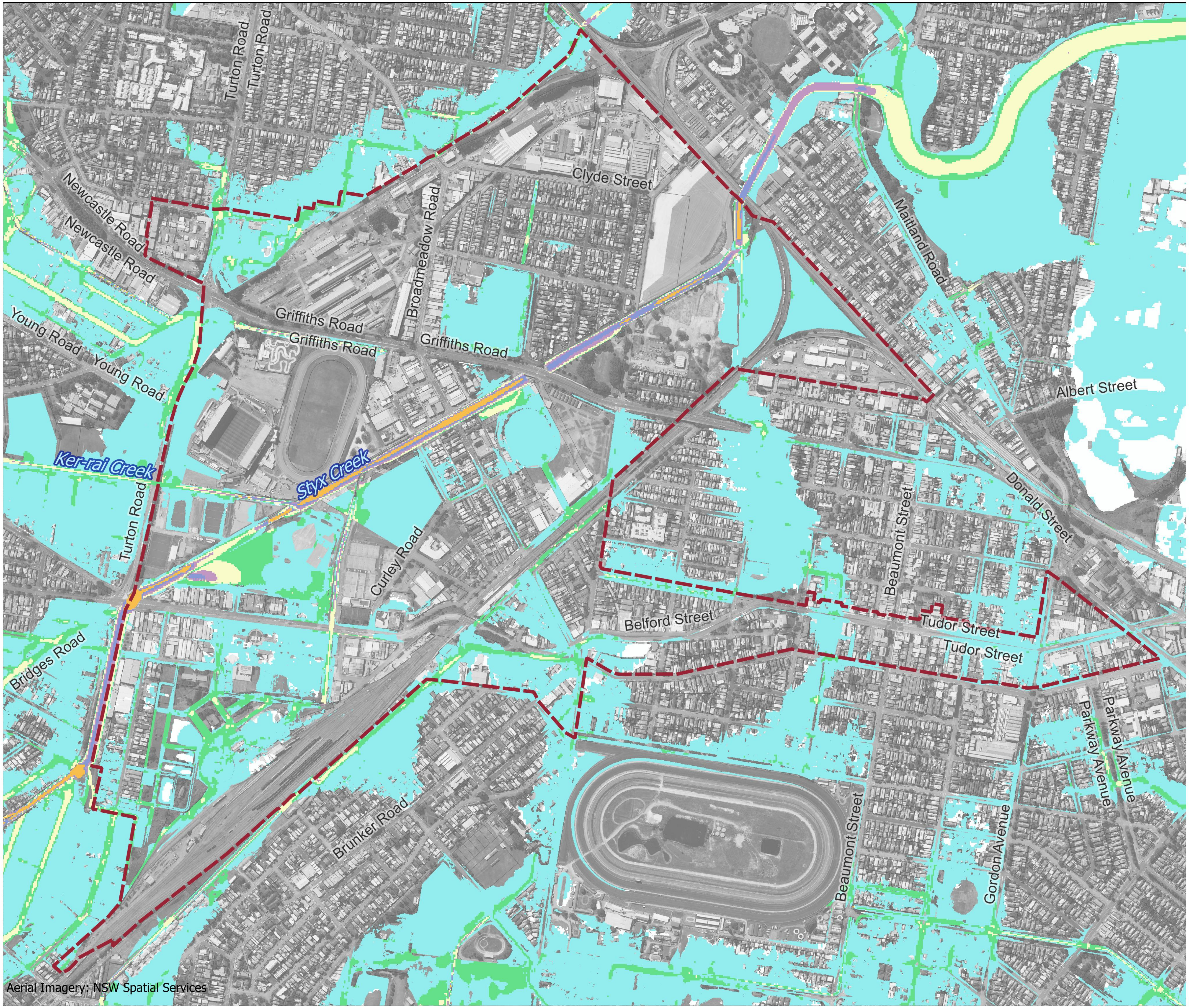
3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-115

Post Development 0.2% AEP Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

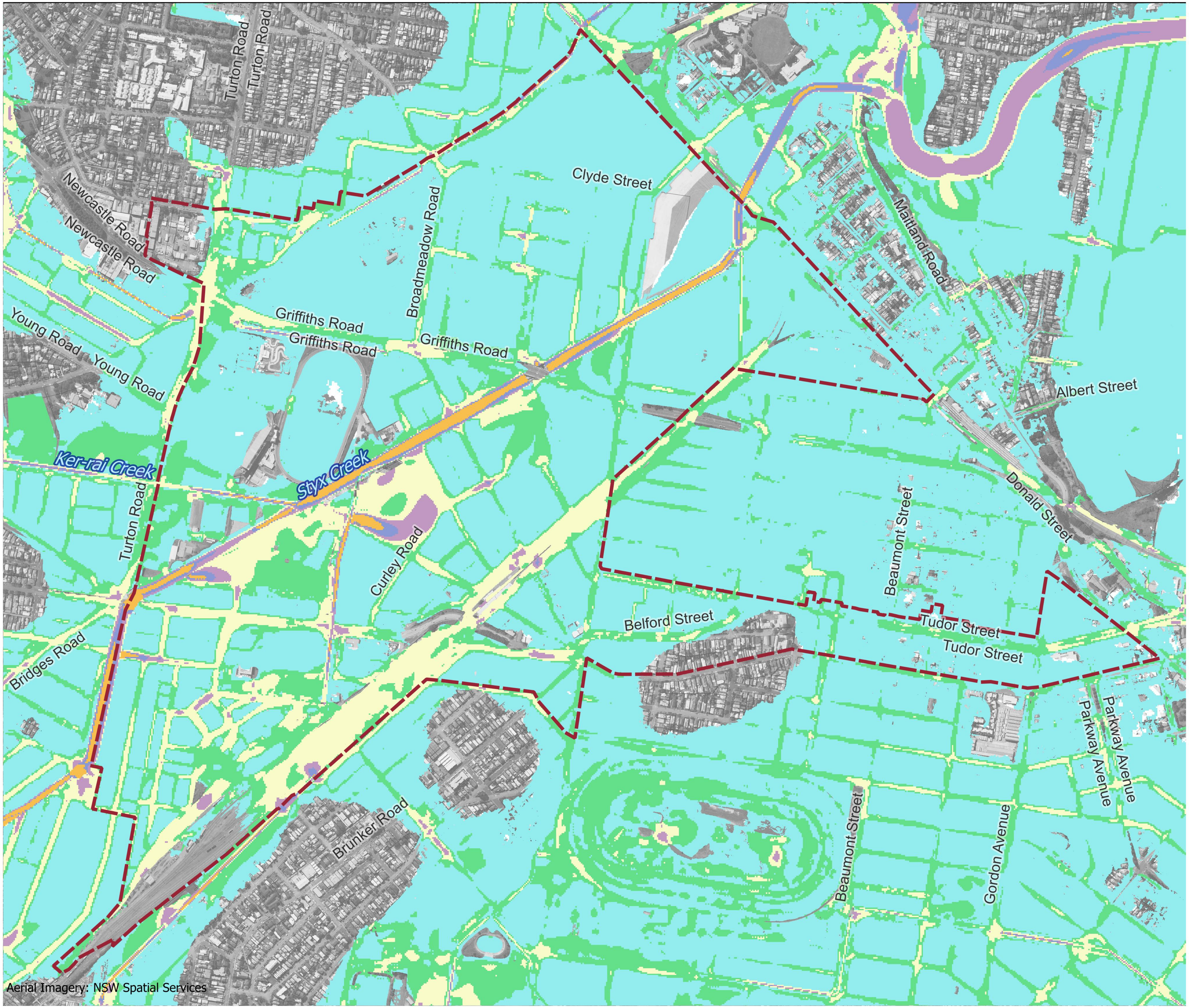
3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-116

Post Development
PMF Peak Flood Velocity

Legend

Study Area

Cadastre

Peak Flood Velocity (m/s)

<=0.01

0.01 - 0.5

0.5 - 1

1 - 2

2 - 3

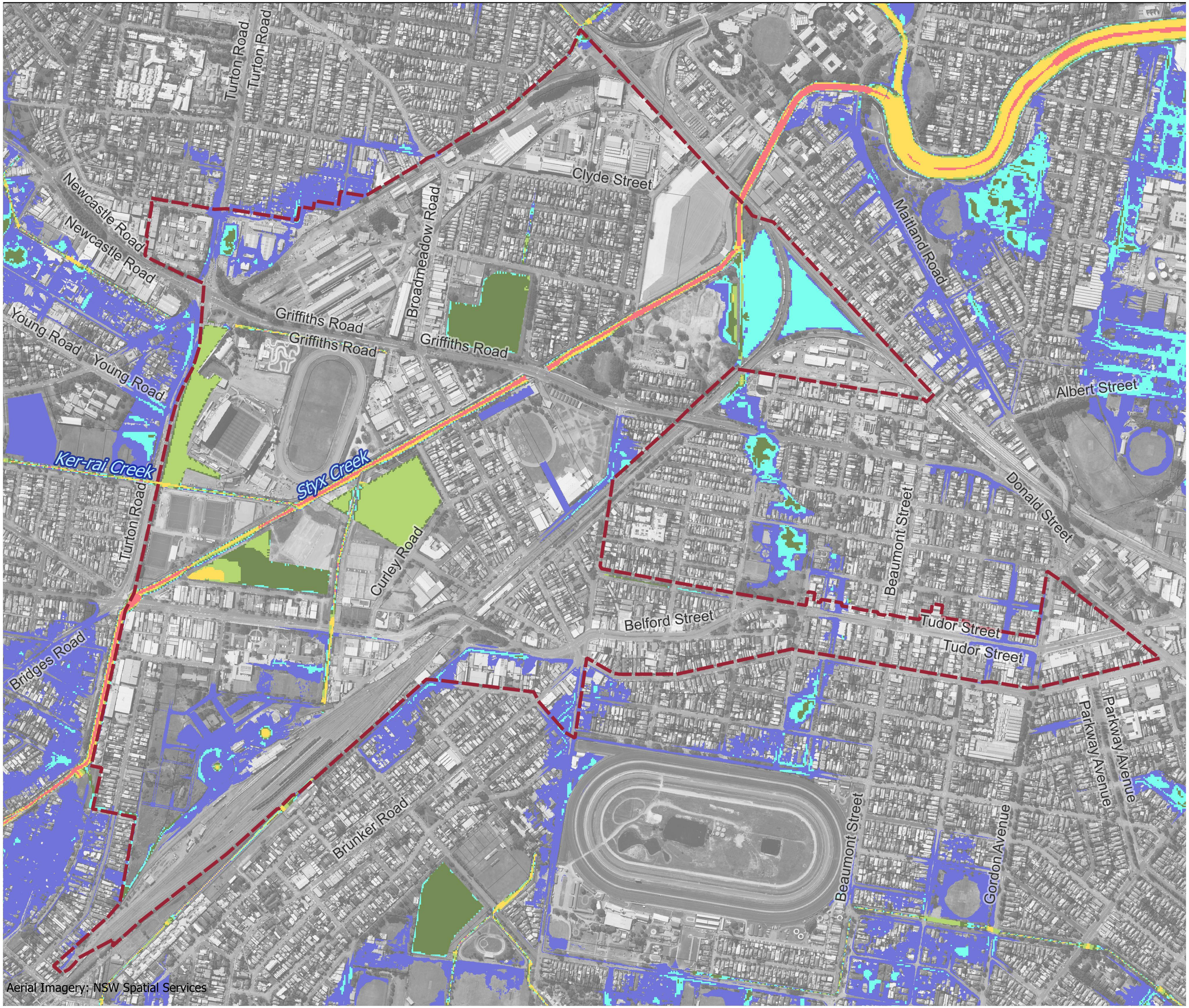
3 - 4

> 4

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-120

Post Development 10% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

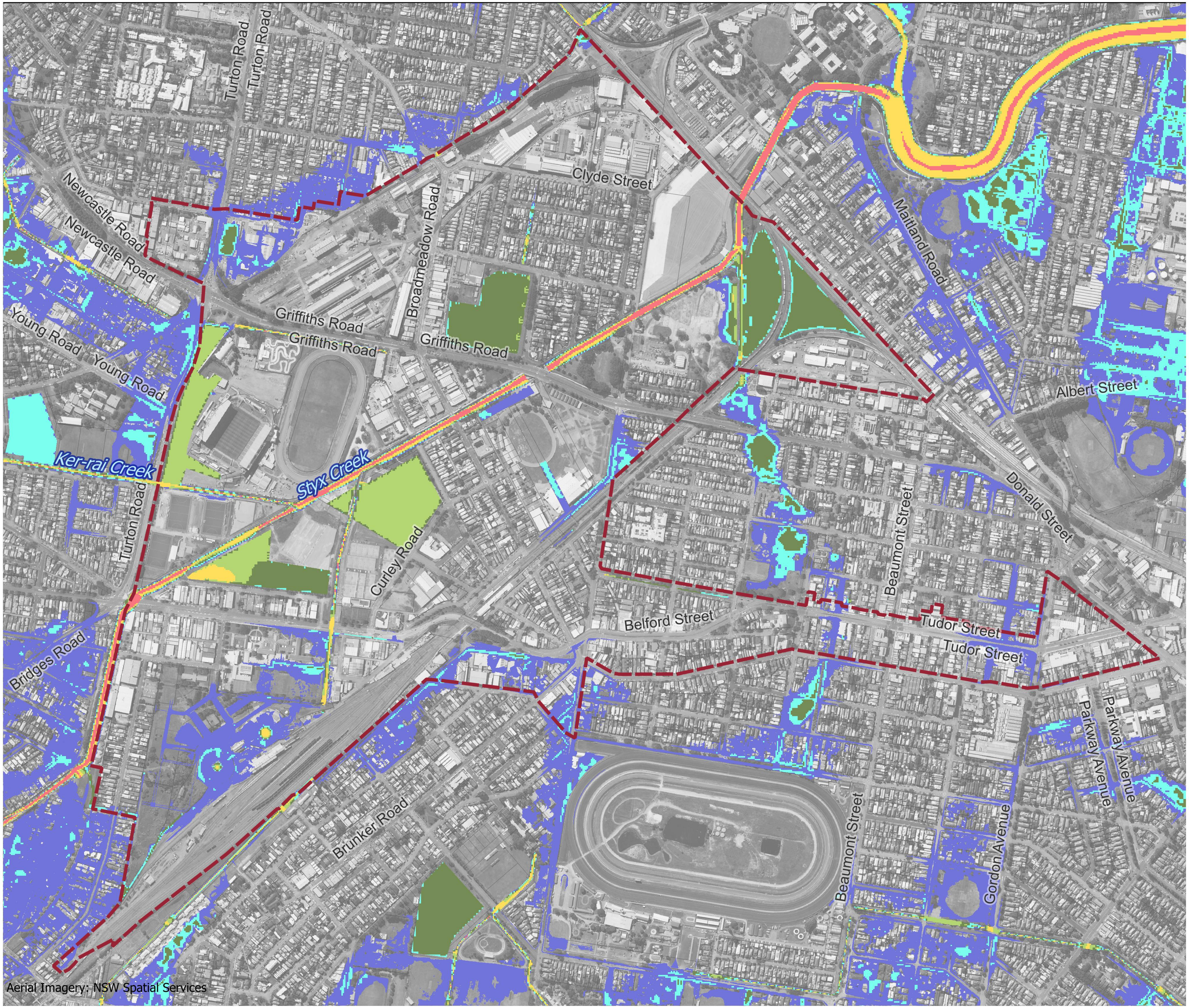
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-121

Post Development 5% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm

N
W E
S

RG-02-122

Post Development 2% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

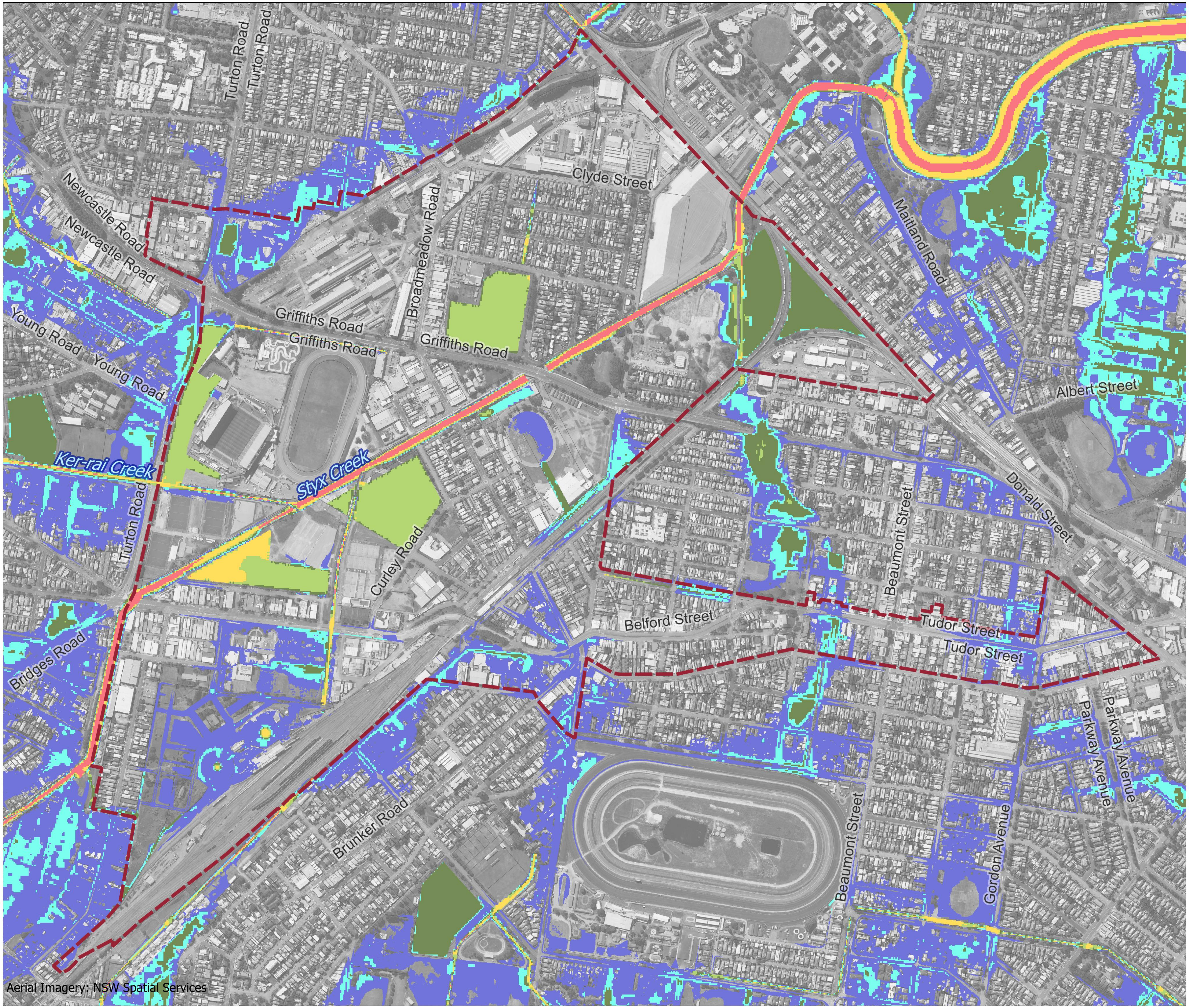
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-123

Post Development 1% AEP Peak Flood Hazard

Legend

- Study Area
- Cadastre

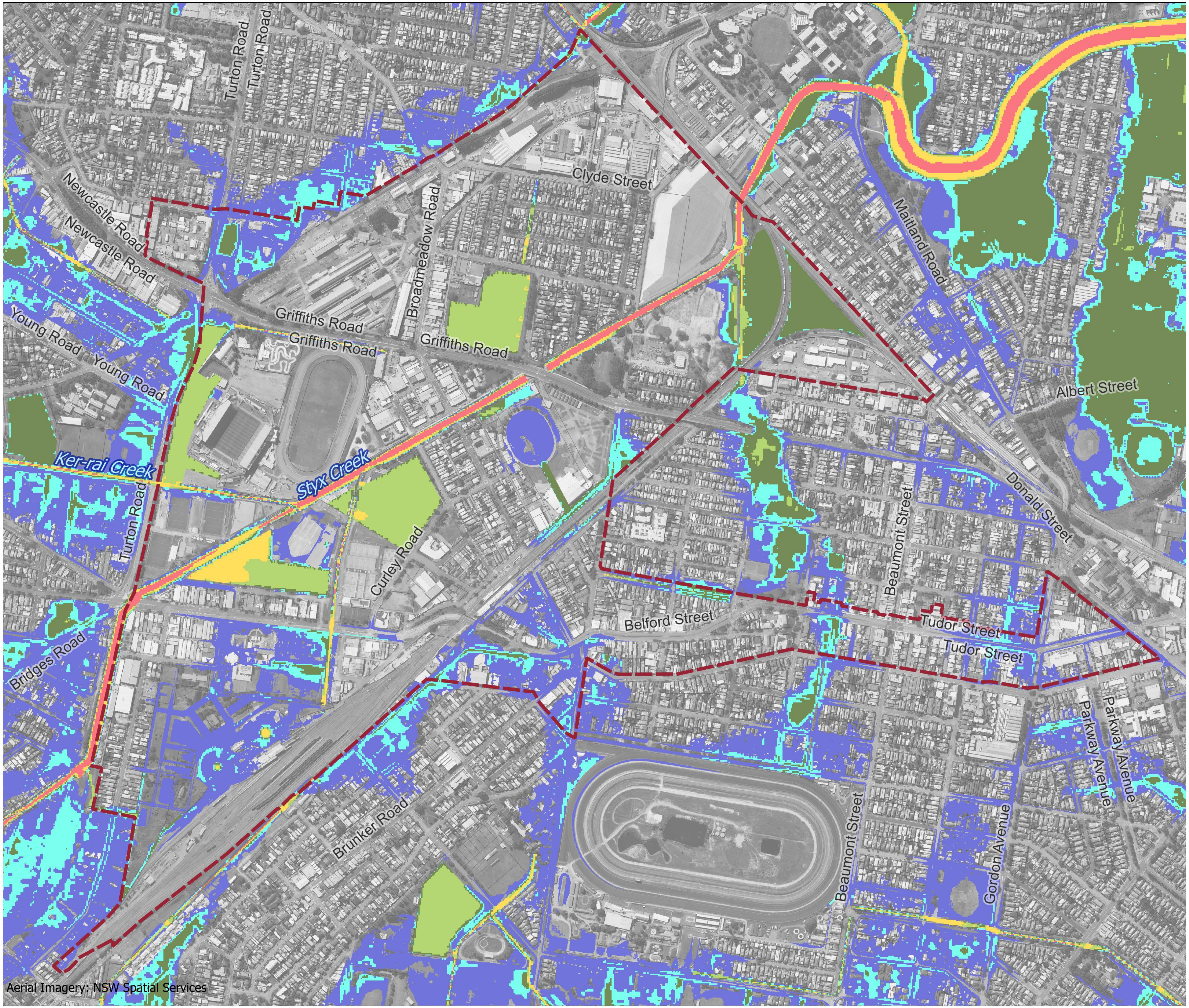
Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-124

Post Development 0.5% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

Peak Flood Hazard

H1 - Generally safe for vehicles, people & buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for vehicles and people

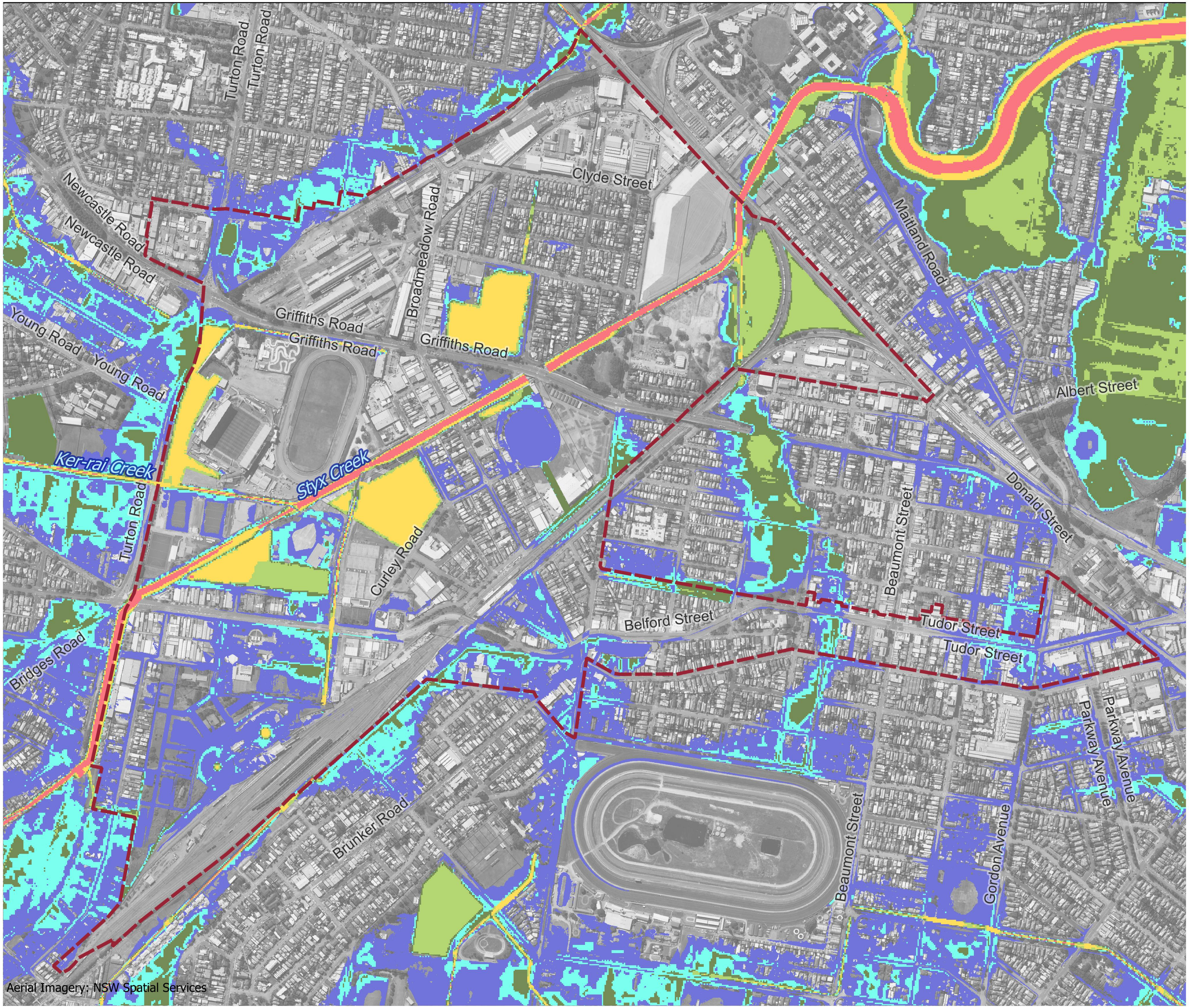
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure

H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-125

Post Development 0.2% AEP Peak Flood Hazard

Legend

Study Area

Cadastre

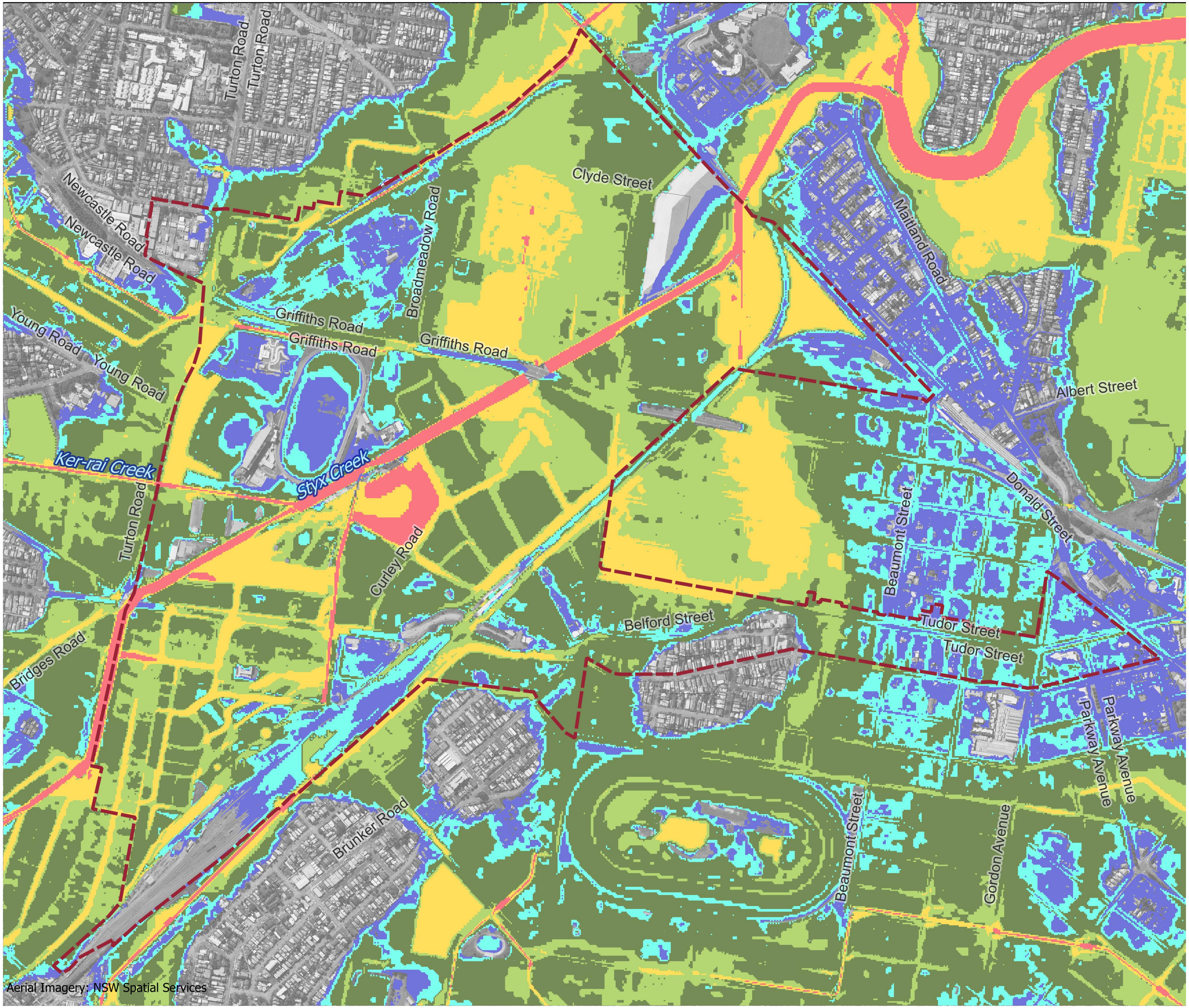
Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-126

Post Development
PMF Peak Flood Hazard

Legend

- Study Area
- Cadastre

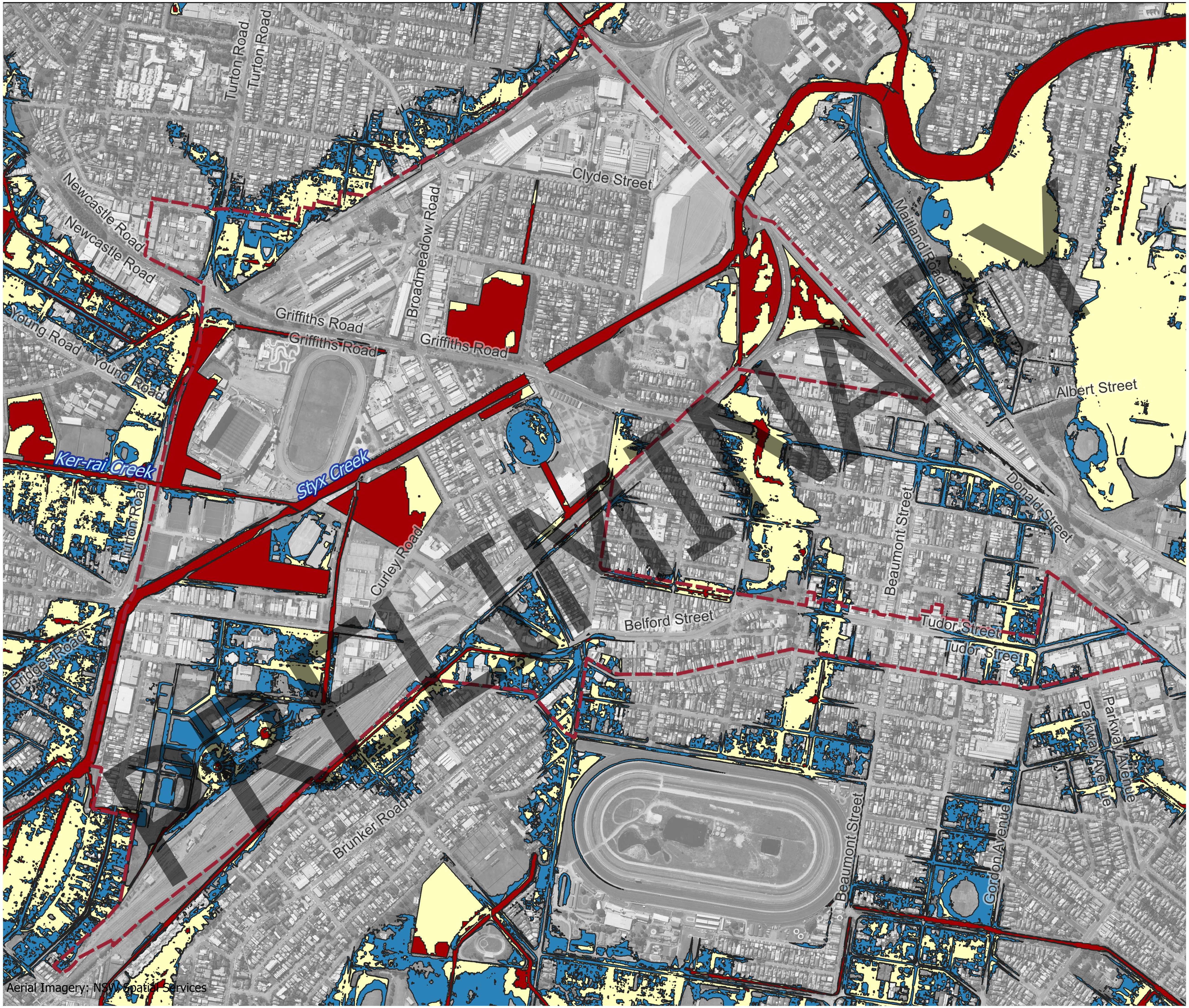
Peak Flood Hazard

- H1 - Generally safe for vehicles, people & buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4 - Unsafe for vehicles and people
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust building types vulnerable to failure
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-127

Post Development 0.5% AEP in 2050 Flood Function

Legend

Study Area

Cadastre

Flood Function

Floodway

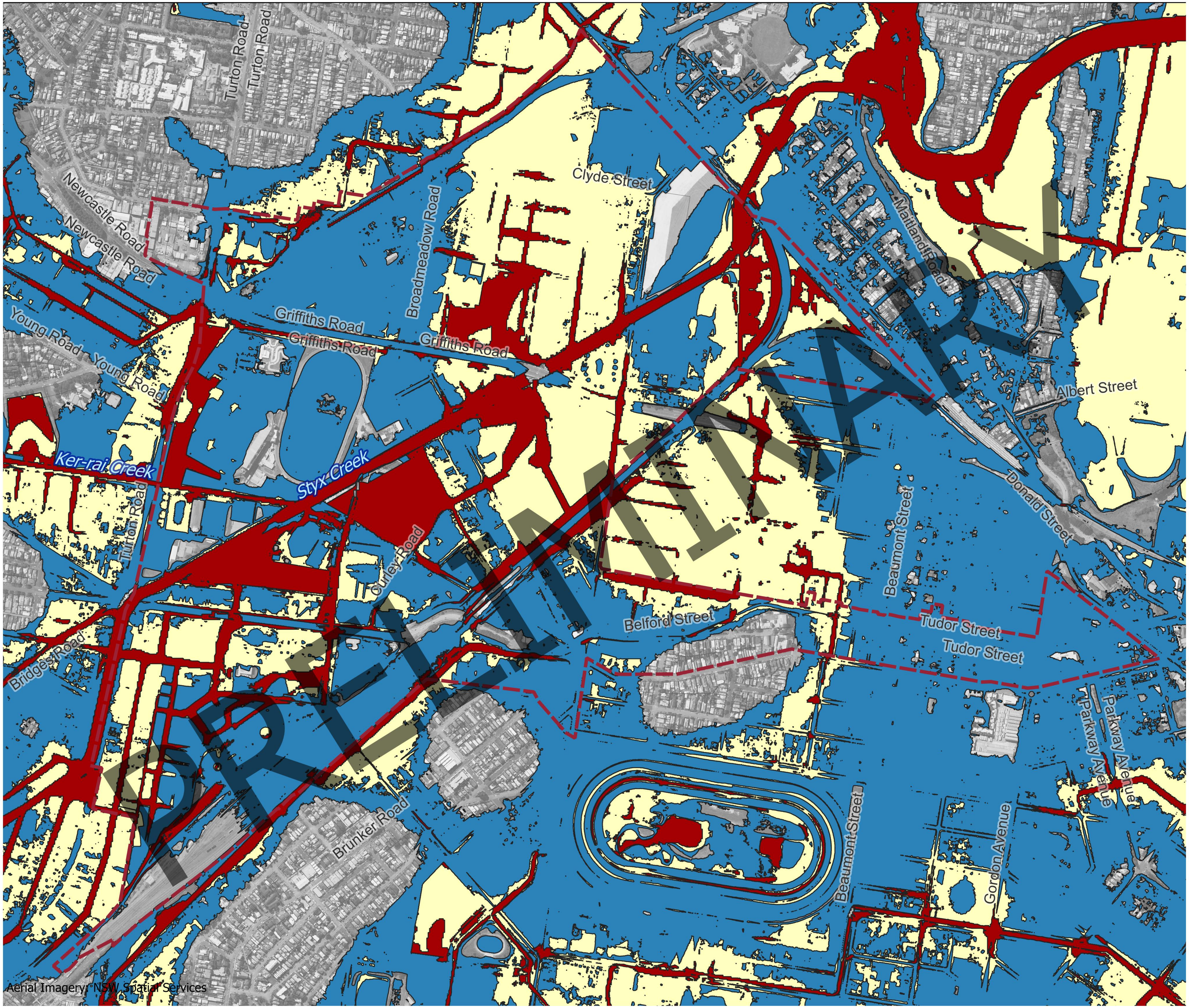
Flood Storage

Flood Fringe

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-128

Post Development PMF Flood Function

Legend

- Study Area
- Cadastre

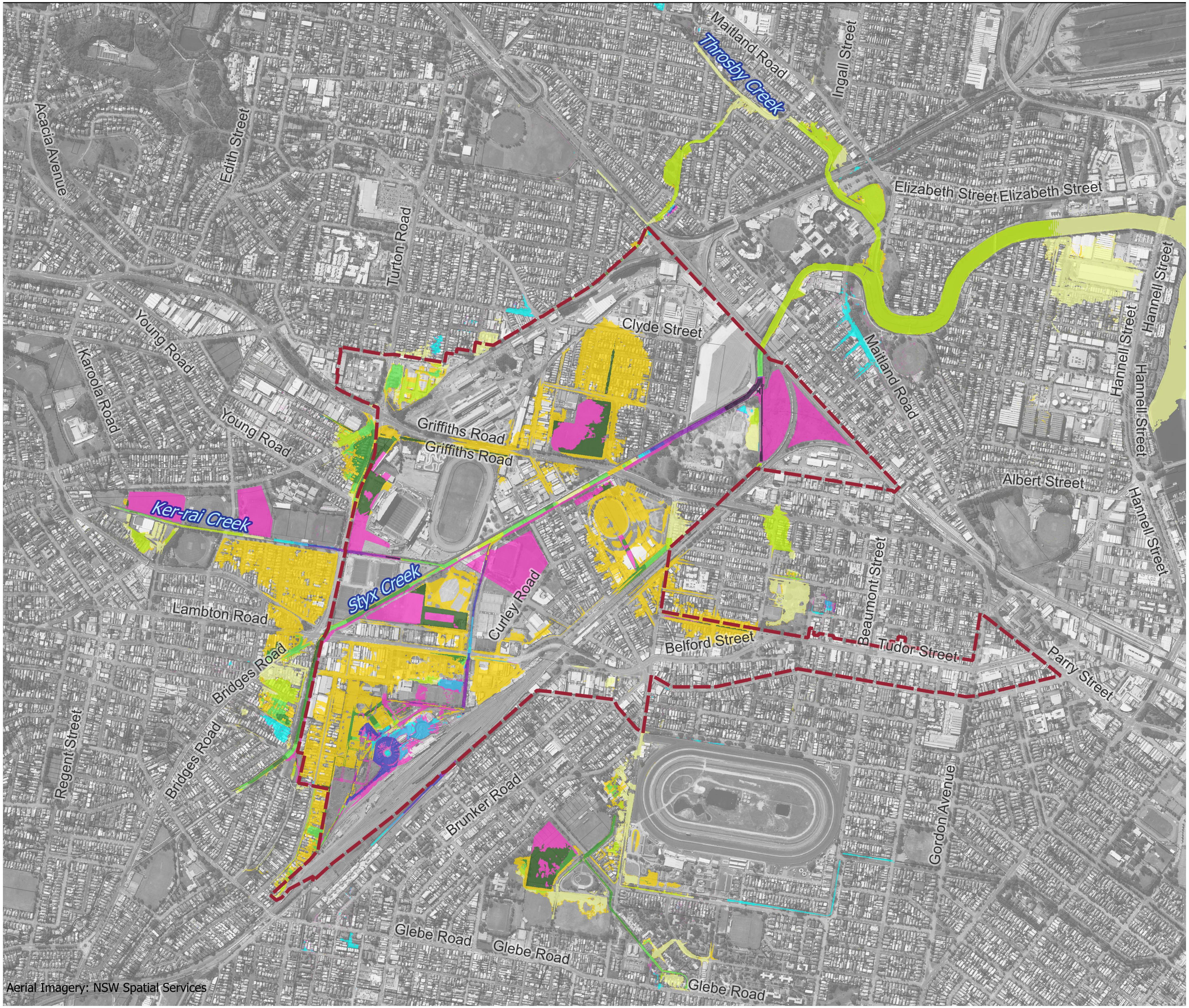
Flood Function

- Floodway
- Flood Storage
- Flood Fringe

0 200 400 m

Scale : 1:10000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-129

Post Development 10% AEP Food Level Impact

Legend

- Study Area
- Cadastre

Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm

N
W E
S

RG-02-130

Post Development 5% AEP Food Level Impact

Legend

- Study Area
- Cadastre

Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm

N
W E
S

RG-02-131

Post Development 2% AEP Food Level Impact

Legend

- Study Area
- Cadastre

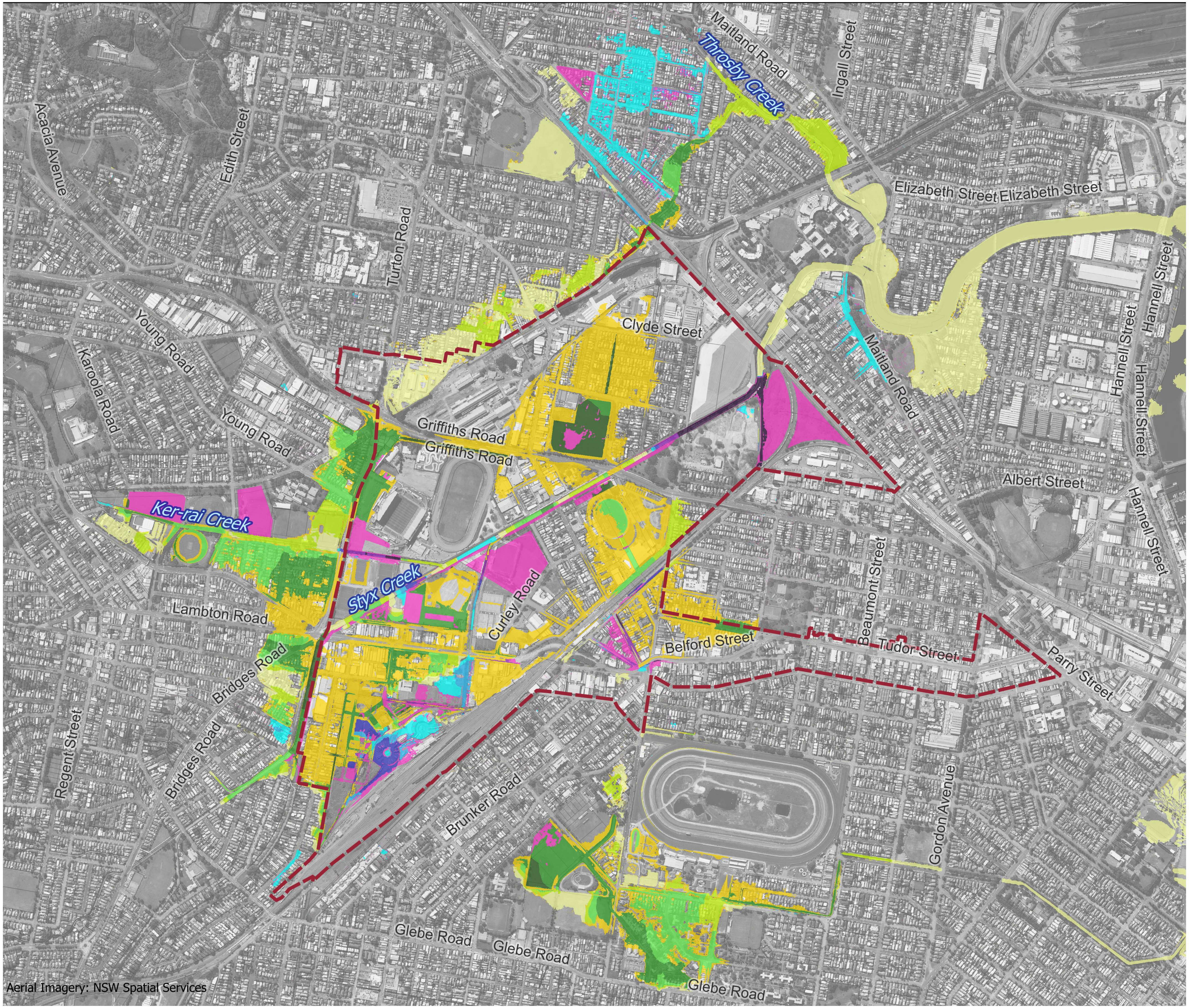
Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-132

Post Development 1% AEP Food Level Impact

Legend

Study Area

Cadastre

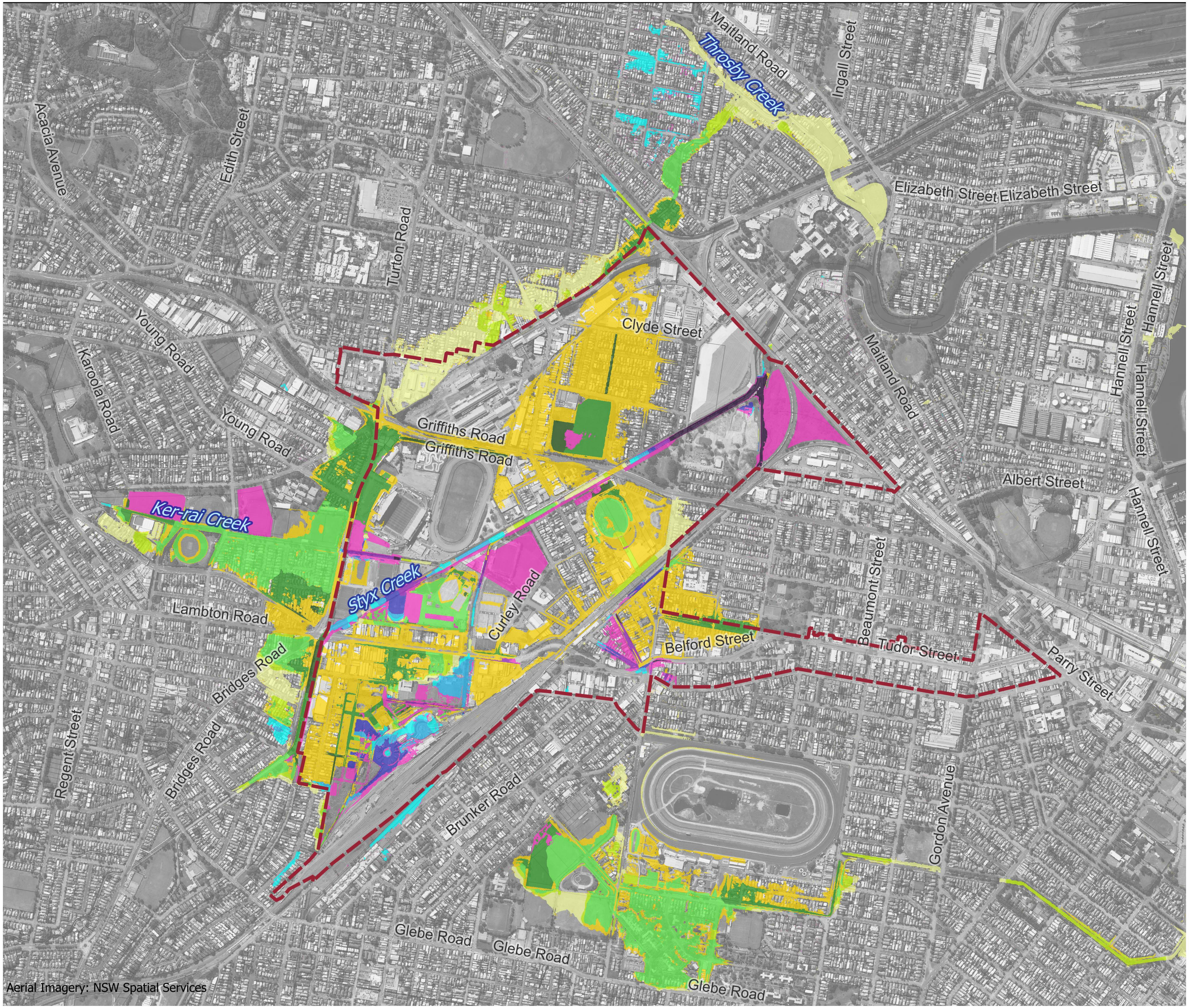
Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-133

Post Development 0.5% AEP Food Level Impact

Legend

Study Area

Cadastre

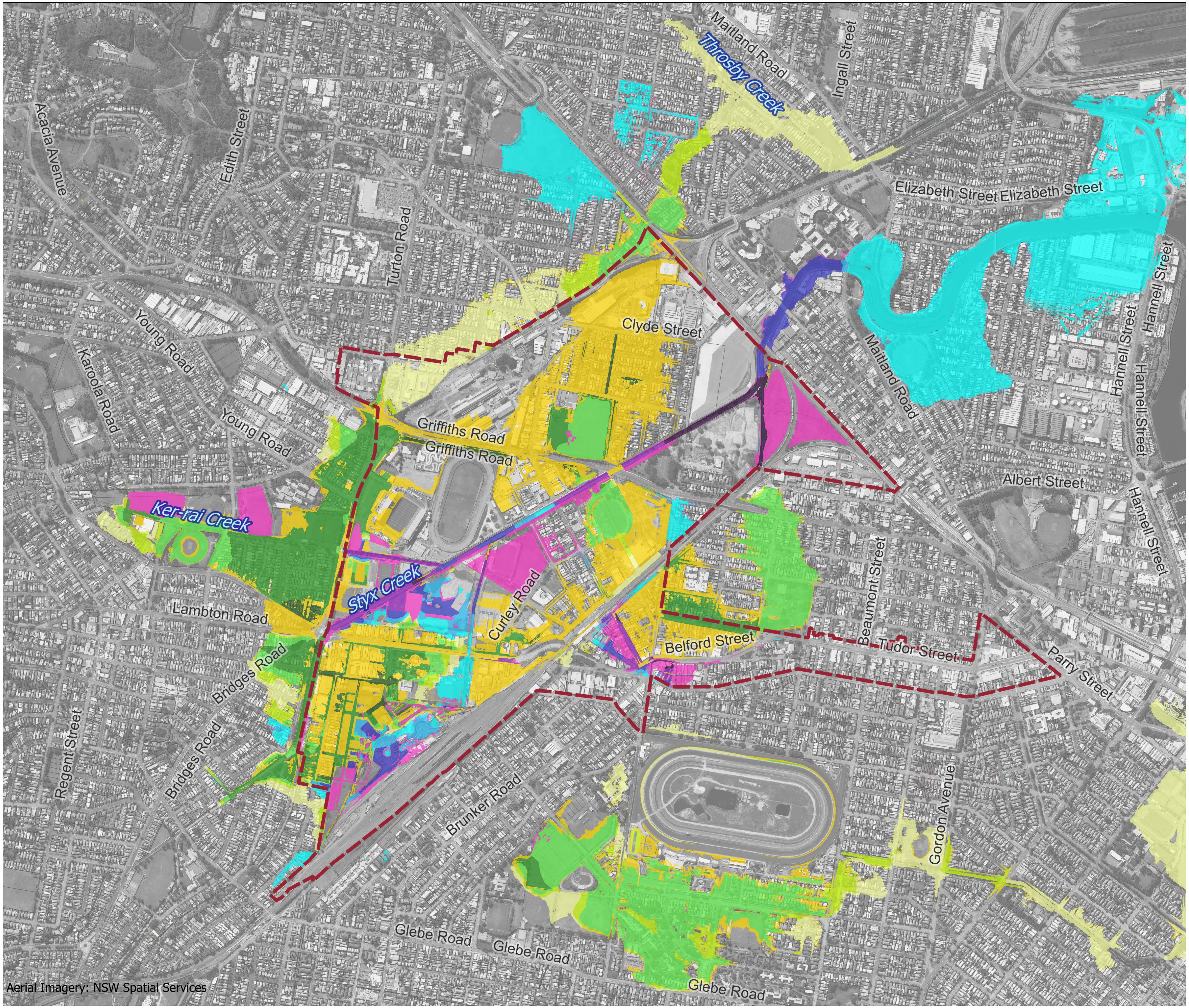
Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-134

Post Development 0.2% AEP Food Level Impact

Legend

Study Area

Cadastre

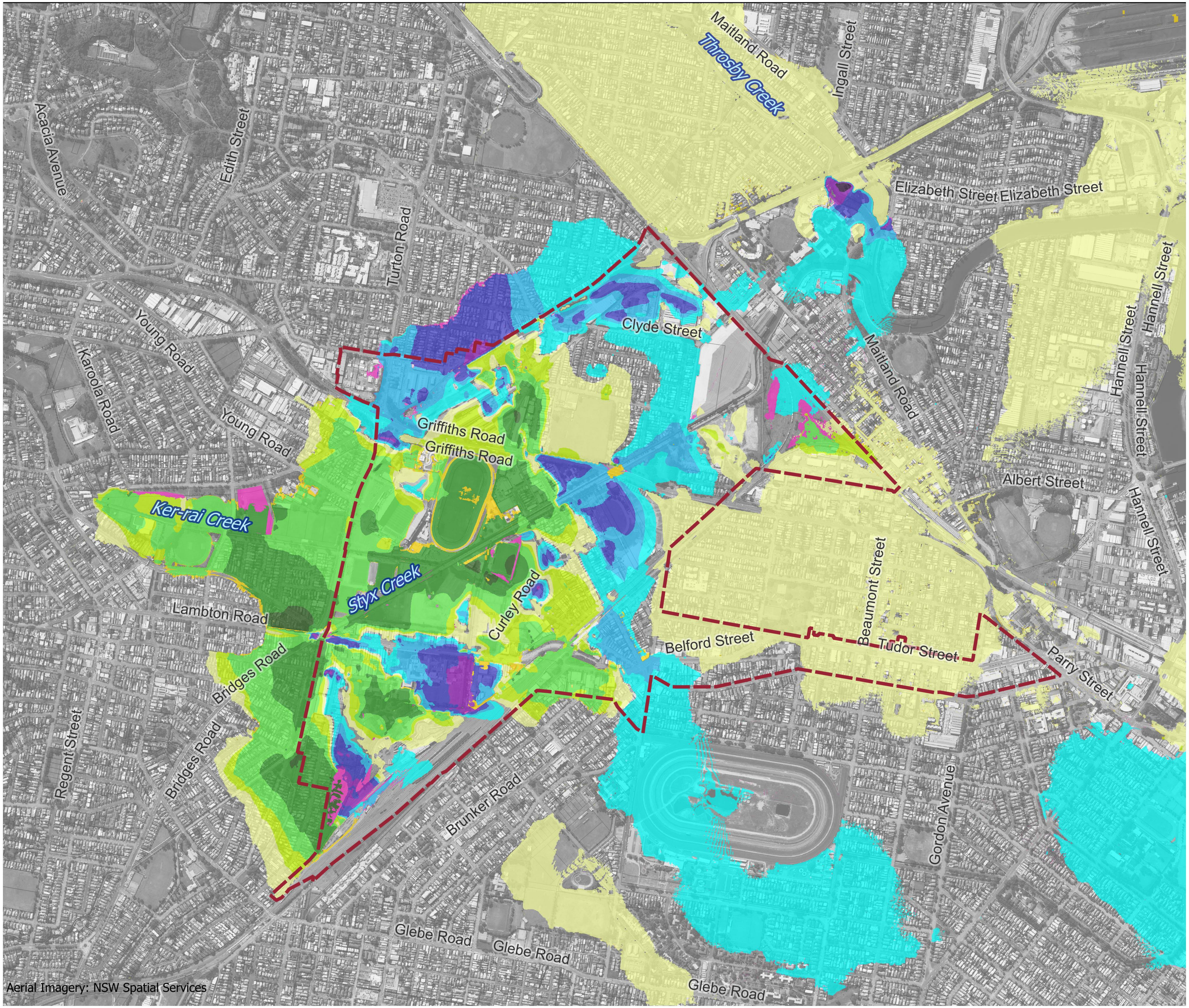
Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-02-135

Post Development
PMF Food Level Impact

Legend

Study Area

Cadastre

Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

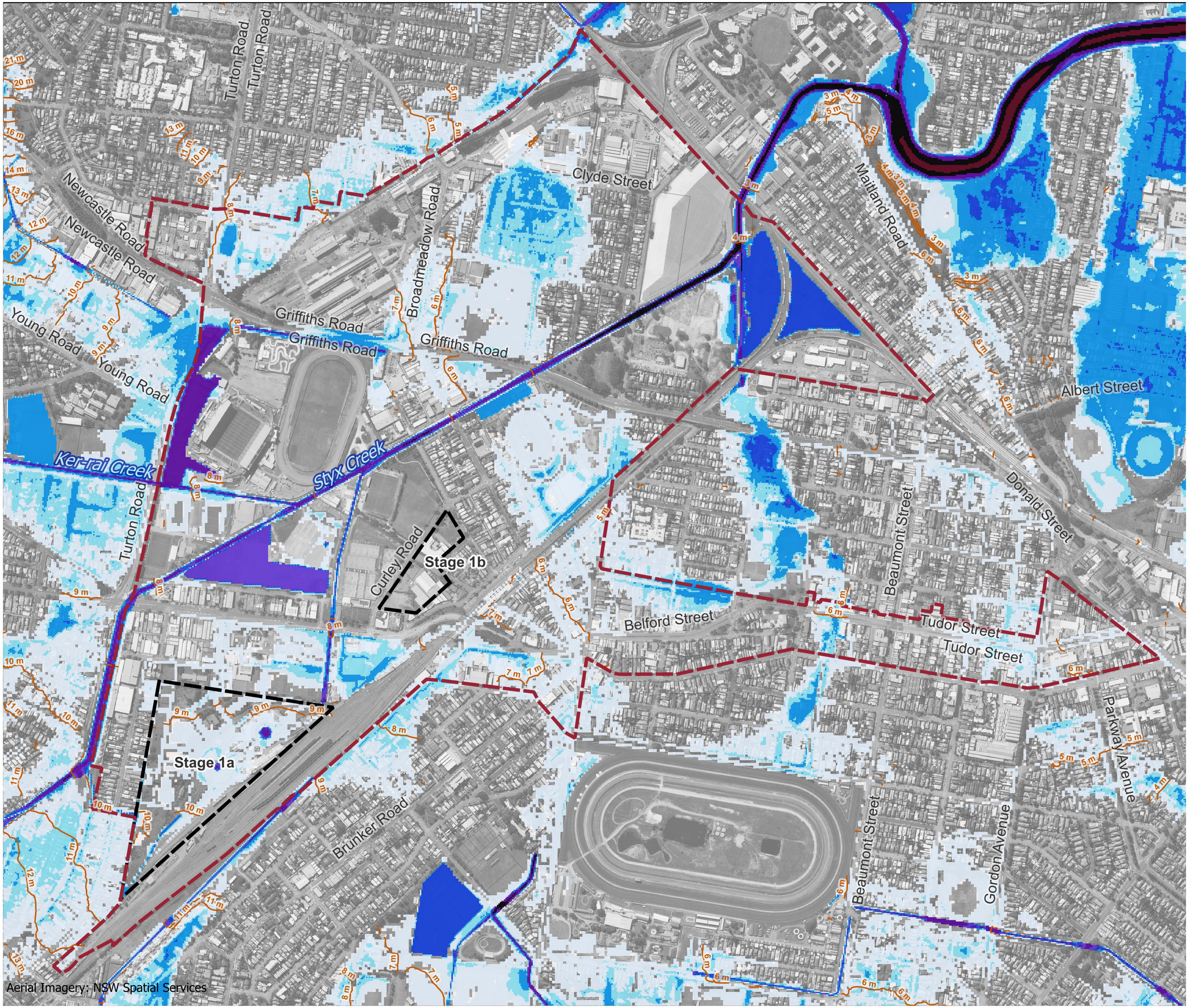
0 200 400 m

Scale : 1:14000@A3
Date : 22 Apr 2024
Revision : 02
Created by : JPS
Coordinate System : MGA 56

Rhelm

Appendix C

First Moves Scenario Flood Mapping



N
W E
S

RG-03-100

Stage 1B
0.5% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

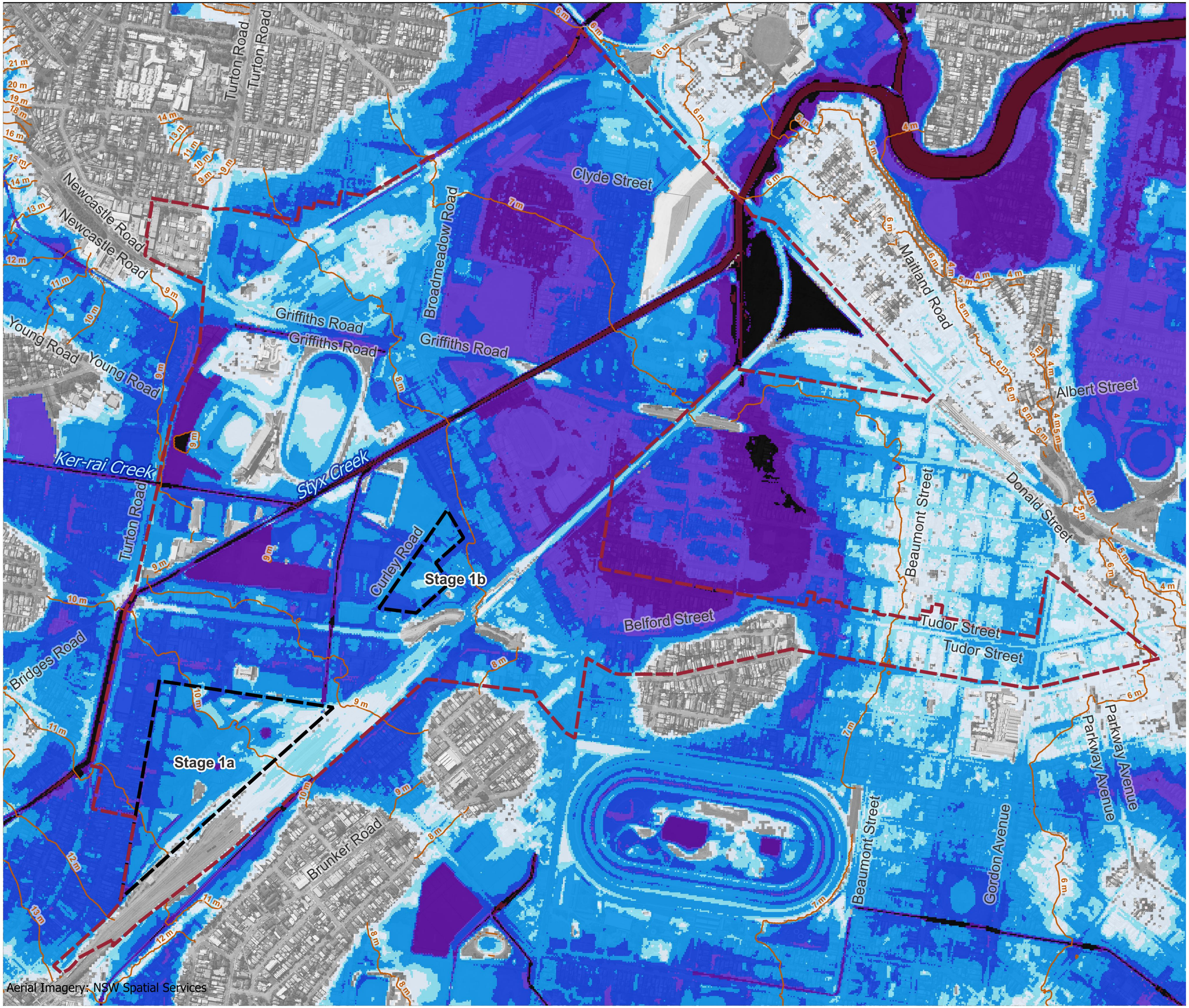
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-101

Stage 1B
PMF Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

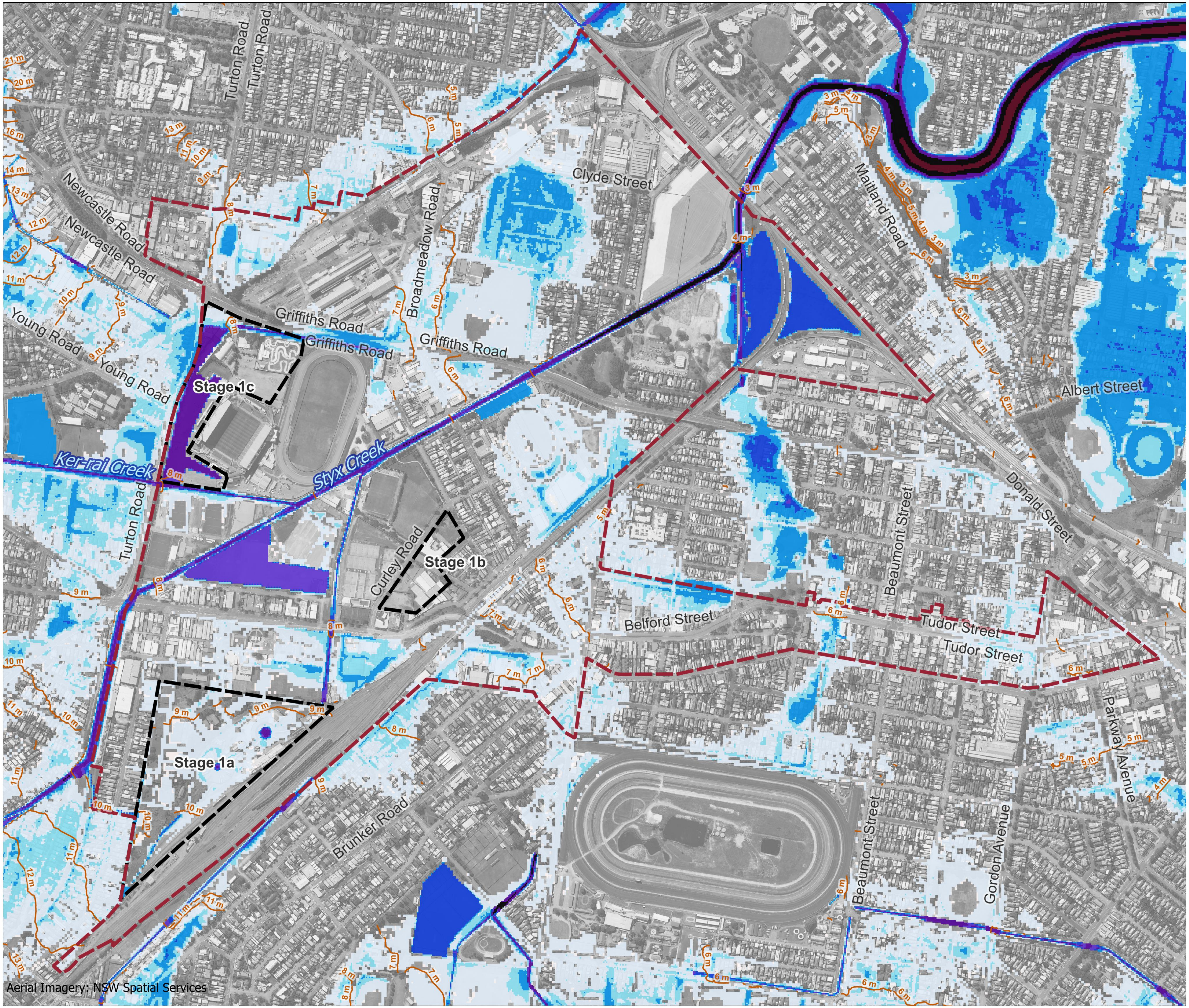
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-102

Stage 1C
0.5% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

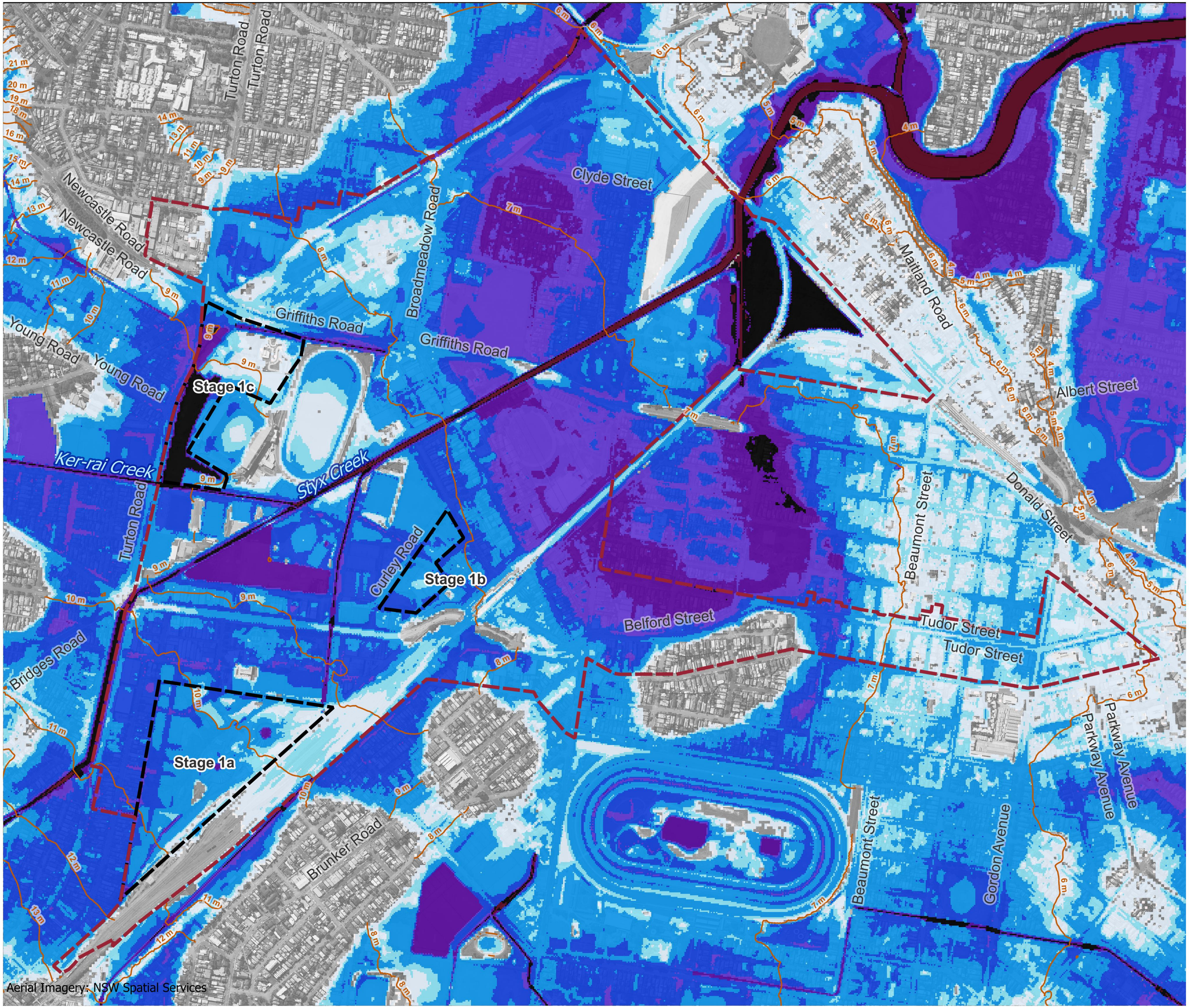
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-103

Stage 1C
PMF Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

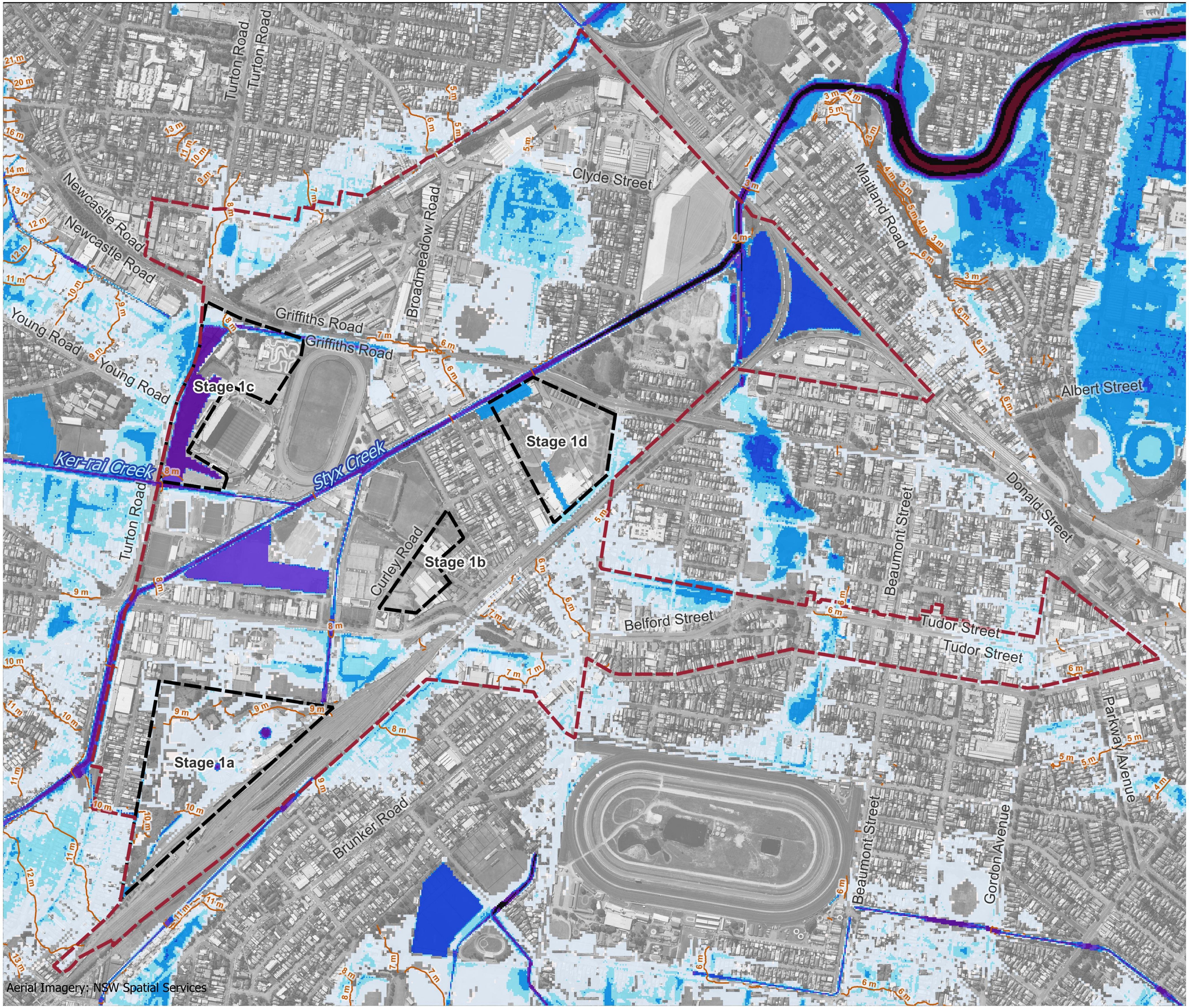
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-104

Stage 1D
0.5% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

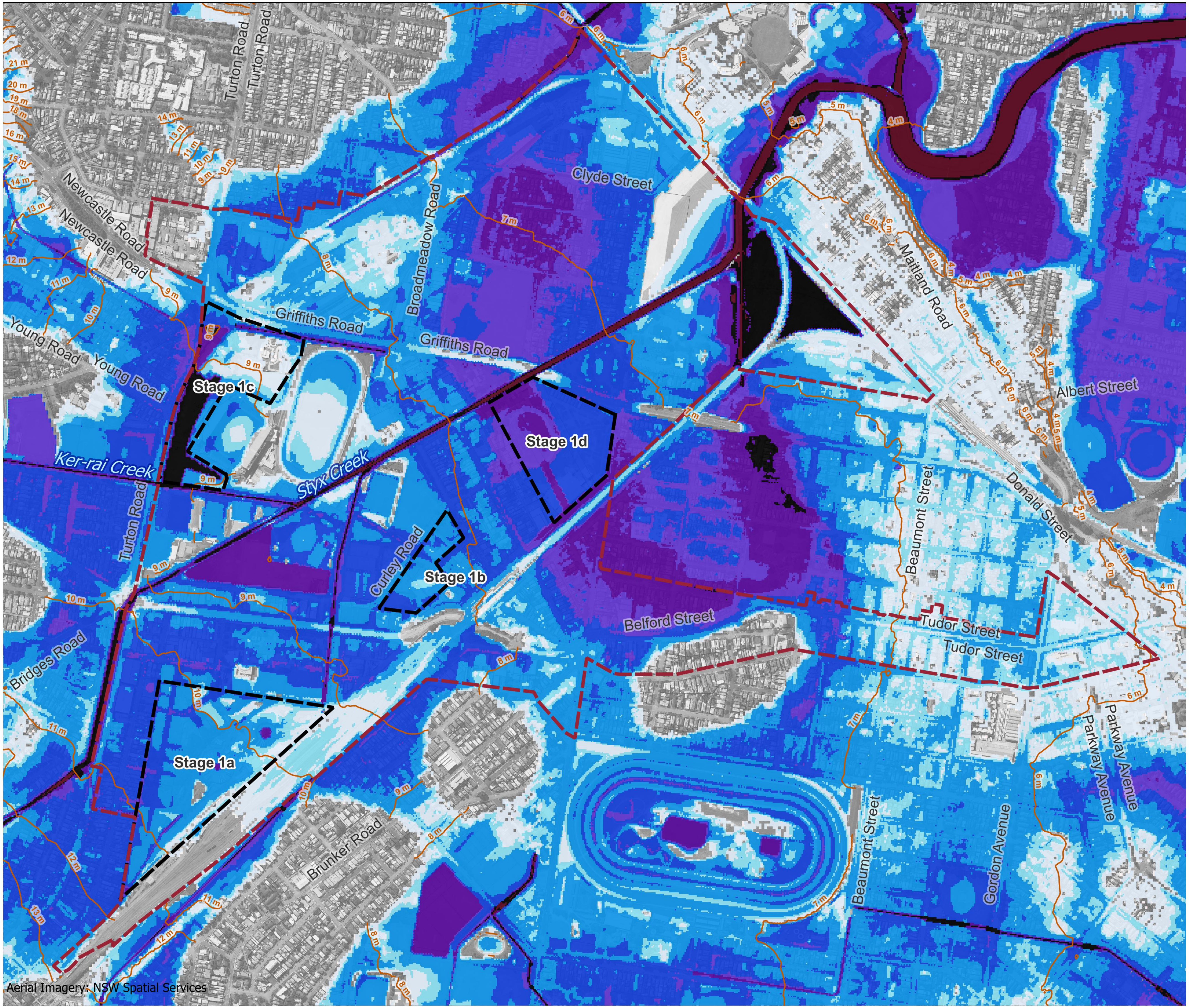
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-105

Stage 1D
PMF Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

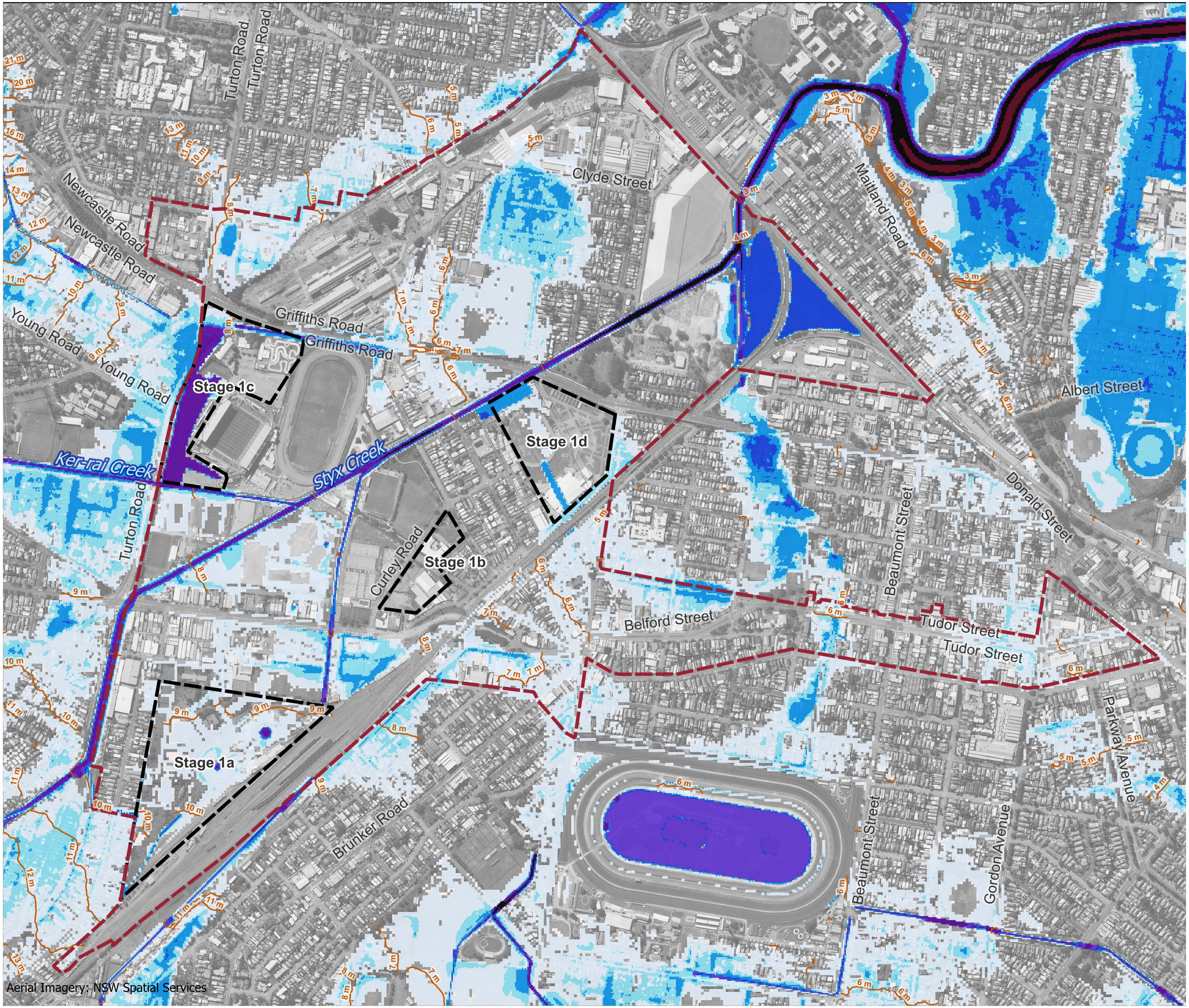
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



N
W E
S

RG-03-106

Stage 1D - Racecourse Basin 0.5% AEP Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

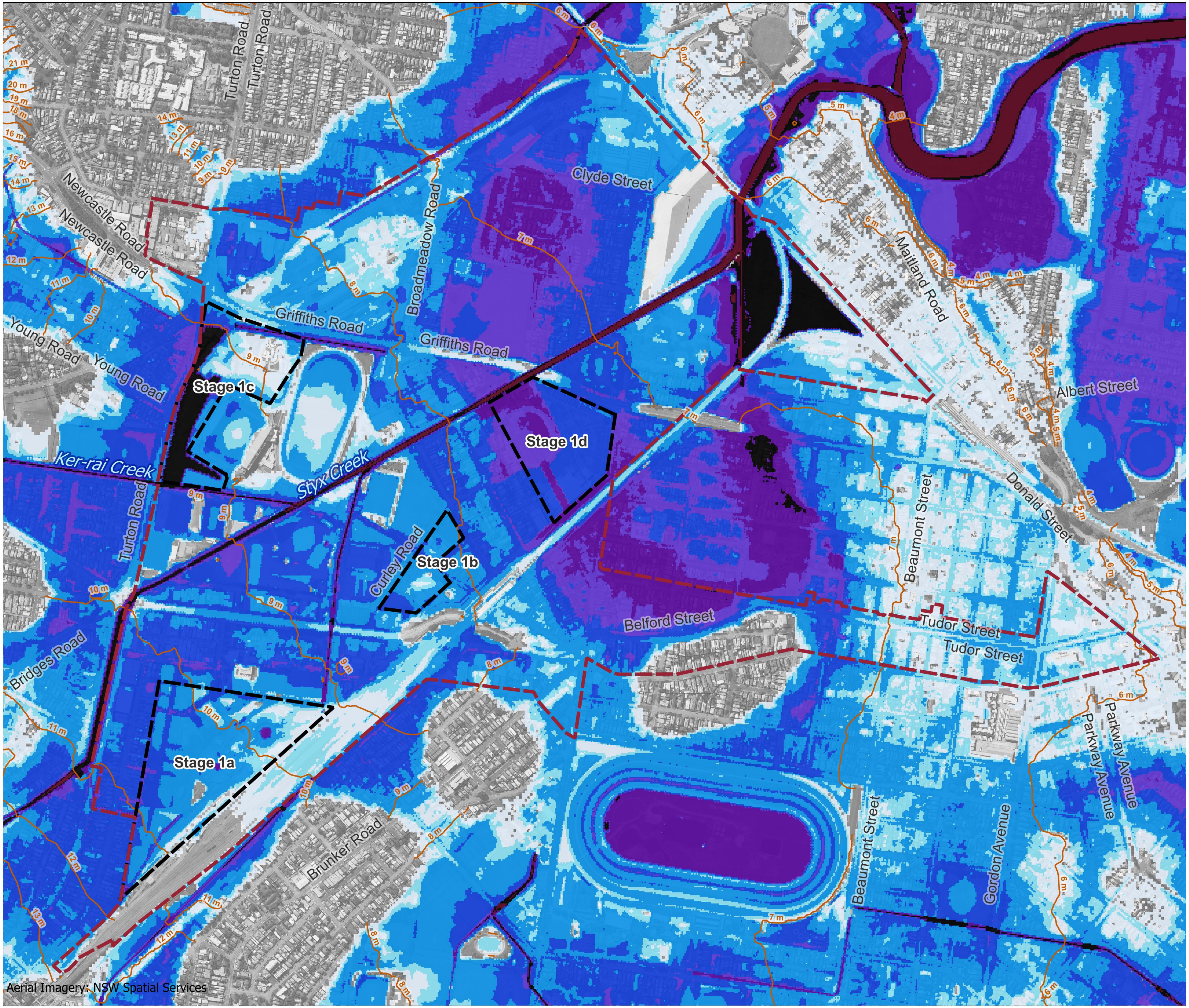
Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

Rhelm



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RG-03-107

Stage 1D - Racecourse Basin
PMF Peak Flood Depth and Elevation

Legend

- Study Area
- First Moves Stage
- Cadastre
- 1m Water Level Contours

Peak Flood Depth (m)

- <= 0.01
- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 4
- > 4

0 200 400 m

Scale : 1:10000@A3
Date : 9 May 2024
Revision : 01
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RG-03-110

Stage 1B
1% AEP Food Level Impact

Scale : 1:14000@A3
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W E
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RG-03-111

Stage 1C
1% AEP Food Level Impact

Legend

- Study Area
- First Moves Stage
- Cadastre

Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

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N
W E
S

RG-03-112

**Stage 1D
1% AEP Food Level
Impact**

Legend

Study Area
First Moves Stage
Cadastre

Flood Level Impact (m)

<= -0.5
-0.5 - -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.5
> 0.5
Was wet, now dry
Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
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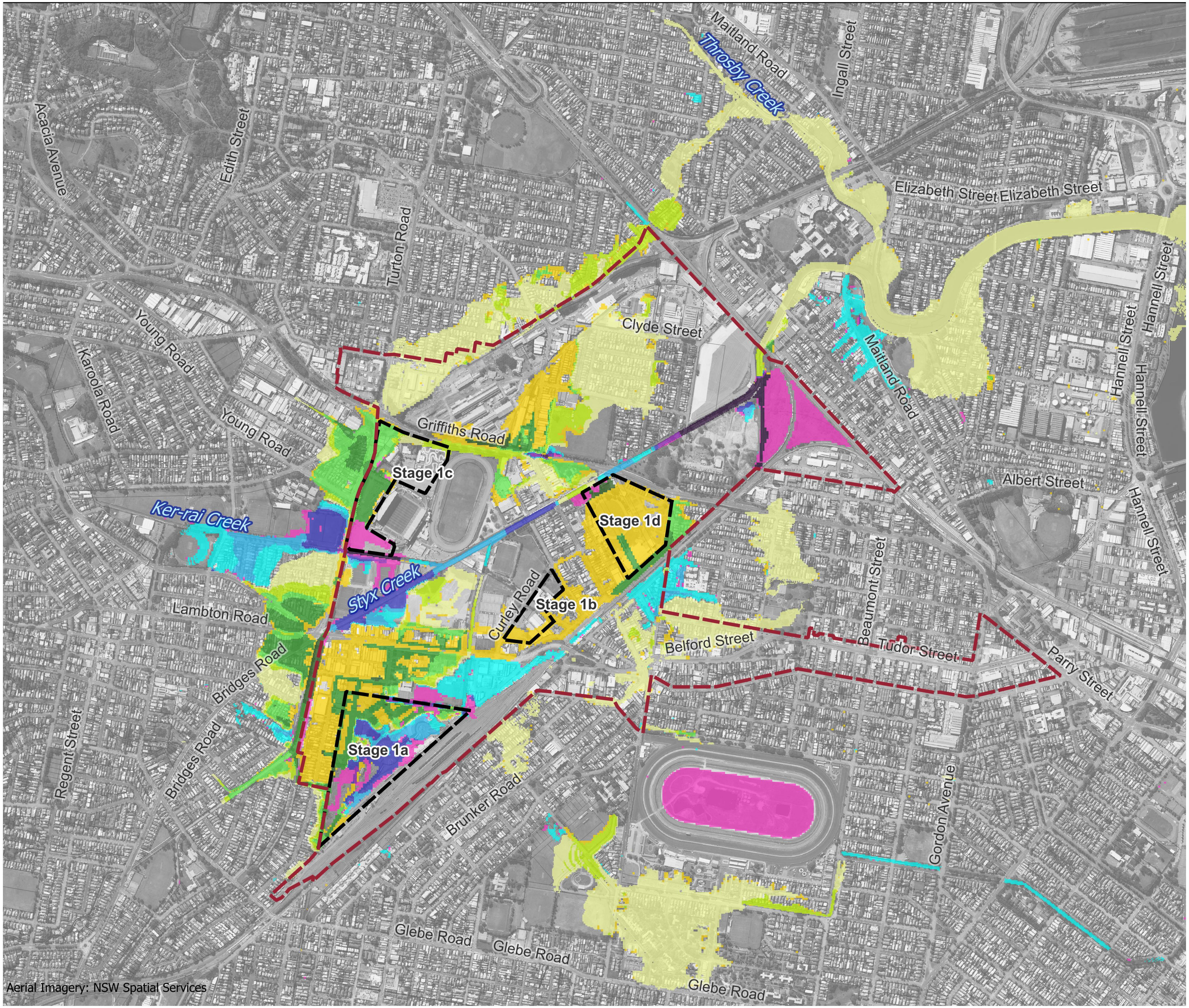

N
W E
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RG-03-113

Stage 1D - Racecourse Basin
1% AEP Food Level Impact

Legend

- Study Area
- First Moves Stage
- Cadastre

Flood Level Impact (m)

- <= -0.5
- -0.5 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- > 0.5
- Was wet, now dry
- Was dry now wet

0 200 400 m

Scale : 1:14000@A3
Date : 9 May 2024
Revision : 01
Created by : JPS
Coordinate System : MGA 56

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